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TRATAMIENTO CON APARATOLOGÍA FUNCIONAL EN PACIENTES CON MALOCLUSIÓN DE CLASE II.

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RESUMEN

Introducción: El tratamiento de las maloclusiones de clase II es un tema de trascendental importancia en la actualidad debido a su alta incidencia en la población. Múltiples aparatos funcionales logran la corrección de estas maloclusiones.

Objetivos: El propósito de la presente revisión bibliográfica consiste en estudiar las distintas alternativas de tratamiento con aparatología funcional capaces de corregir las maloclusiones de clase II, analizar los efectos que producen tanto a nivel dentoalveolar como en el crecimiento mandibular o en el maxilar, y determinar cómo mejorar la práctica clínica diaria de estos tratamientos.

Metodología: Una búsqueda bibliográfica avanzada se realizó en las bases de datos *PubMed, Medline Complete, Academic Search Ultimate* y *Google Scholar,* en la que se seleccionaron 54 artículos en inglés o español publicados en revistas de impacto.

Discusión: Los estudios demuestran que se puede lograr el avance mandibular con la ayuda de aparatología funcional, además de corregir defectos dentoalveolares y estos varían en función del aparato. El grado de colaboración es importante y existen dispositivos que permiten evaluarlo. En pacientes poco colaboradores se recomienda el empleo de aparatología funcional fija frente a la removible.

Conclusiones: Los Activadores, Bionator, Bimler, Frankel II, Twin Block, Herbst y Forsus™ son capaces de corregir las maloclusiones de clase II, produciendo cambios esqueléticos y dentoalveolares. Los microsensores Theramon® mejoran la práctica clínica diaria permitiendo al ortodoncista evaluar el grado de colaboración de los pacientes.

ABSTRACT

Introduction: The treatment of class II malocclusions is an issue of transcendental importance nowadays due to it´s high incidence in the population. Multiple functional appliances achieve the correction of these malocclusions.

Objectives: The purpose of this bibliographic review is to study the different treatment alternatives with functional appliances able to correct class II malocclusions, to analyze the dentoalveolar effects they produce and on mandibular or maxillary growth, and determine how to improve the daily clinical practice of these treatments.

Methodology: An advanced bibliographic search was carried out using the databases PubMed, Medline Complete, Academic Search Ultimate and Google Scholar, in which 54 articles in English or Spanish published in high impact journals were selected.

Discussion: Studies show that mandibular advancement can be achieved with the help of functional appliances, in addition to correcting dentoalveolar defects that vary depending on the appliance. The compliance is important and there are devices that can evaluate it. In patients with low compliance, the use of fixed functional appliances is recommended over removable ones.

Conclusions: The Activators, Bionator, Bimler, Frankel II, Twin Block, Herbst and ForsusTM are able to correct class II malocclusions, producing skeletal and dentoalveolar changes. Theramon® microsensors improve daily clinical practice by allowing the orthodontist to assess the degree of collaboration of patients.

ÍNDICE

INTRODUCCIÓN

I. Crecimiento mandibular

Conocer el funcionamiento del crecimiento mandibular es esencial para poder actuar sobre él[1]. Se determina que el conocimiento de la fisiología de este proceso, supone una mejora en la práctica clínica ortodóncica de la aparatología funcional[1].

Para comprender el crecimiento mandibular, es necesario en primer lugar comprender el crecimiento craneofacial[2,3].

Se entiende por crecimiento un proceso en el cual diferentes estructuras sufren variaciones y cambios proporcionales, en diferentes direcciones[3].

El crecimiento craneofacial se produce principalmente como consecuencia de tres procesos que ocurren de manera simultánea: remodelación, desplazamiento e incremento de tamaño[3]. La remodelación de los huesos se produce por dos tipos de células: los osteoblastos, encargados de formar hueso, y los osteoclastos, encargados de reabsorberlo[2]. Debido a este proceso y al crecimiento de los huesos, estos sufren un desplazamiento, que puede ser primario o secundario[2,3]. El primario se produce debido al aumento de tamaño del mismo hueso, mientras que el secundario se debe a los cambios que sufren los huesos circundantes[3].

A lo largo de la historia, han surgido diferentes teorías que tratan de explicar la función del cóndilo en el proceso de crecimiento de la mandíbula[1].

Entre los autores clásicos, Sarnat propone que el cóndilo es el lugar con más actividad e importancia de dicho proceso, siendo la única estructura encargada del crecimiento mandibular[1]. En 1940, Brodie determina que la dirección de crecimiento del cóndilo es hacia atrás, lo que produce un desplazamiento de la mandíbula hacia delante[1]. Posteriormente, surge por primera vez la hipótesis de la existencia de más de un punto crucial en el crecimiento de la mandíbula, es decir, se abandona la idea de que el cóndilo es el único centro encargado de regular y mediar este proceso[1].

En 1954, Scott confirma que la dirección de crecimiento del cóndilo es hacia arriba y hacia atrás (posterosuperior) y que, junto a la acción de otras fuerzas, da lugar a un desplazamiento de la mandíbula hacia delante y hacia abajo[1]. Bjork y Koski indicaron que el crecimiento del cóndilo no era tan determinante en el proceso de crecimiento y desarrollo de la mandíbula[1].

En 1955 Bjork propuso el concepto de "crecimiento rotacional de la mandíbula", es decir, indica que el cuerpo de la mandíbula, mientras crece, experimenta una rotación o cambio de angulación con respecto a la base craneal anterior (SNL)[3]. La rotación anterior se produce cuando el ángulo formado por el cuerpo mandibular y SNL se reduce, y una rotación posterior cuando aumenta (Fig.1)[3].

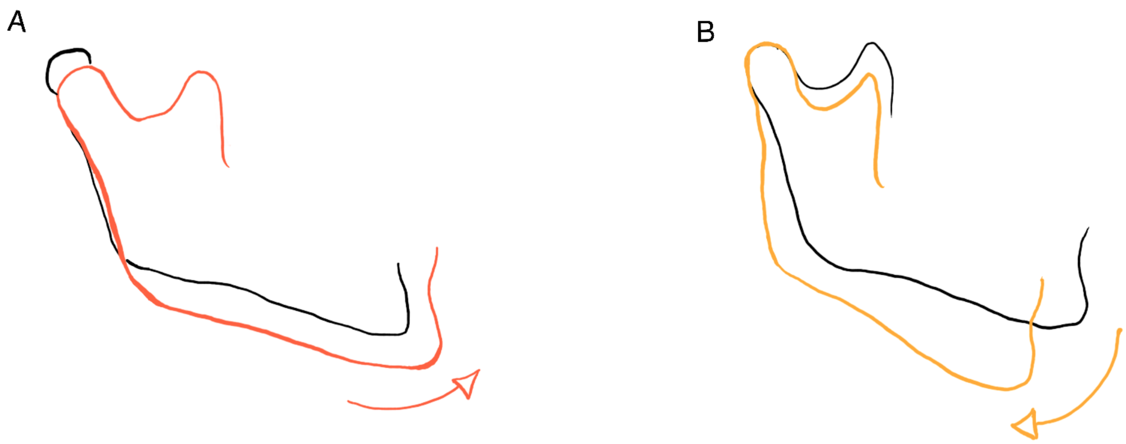

Fig.1. Representación de los tipos de crecimiento rotacional de la mandíbula: A) Rotación anterior de la mandíbula; B) Rotación posterior de la mandíbula. Ilustración de elaboración propia.

La rotación completa que experimenta la mandíbula viene dada por el conjunto de la rotación primaria, que es la rotación que tiene la propia estructura mandibular cuando crece, a causa de las diferentes remodelaciones que sufre; y la rotación secundaria, que consiste en el desplazamiento de la misma con respecto a la base craneal anterior[3,4].

En 1983, dicho autor realizó una superposición de diferentes cefalometrías de pacientes en crecimiento y evaluó la tendencia del mismo en función del biotipo del paciente[5]. Propuso una serie de estructuras que podían servir de referencia para evaluar la rotación de la mandíbula conocidas como signos de crecimiento rotacional extremo que fueron: la inclinación de la cabeza del cóndilo, la curvatura del canal dentario inferior, la morfología del borde inferior mandibular, la sínfisis mandibular, los ángulos interincisales, interpremolares o molares y el contorno anterior del mentón[5,6].

En la década de 1960, aparece la Teoría de la matriz funcional de la mano de Moss, quién propuso que el cóndilo crece como consecuencia de una respuesta adaptativa que se produce para mantener una relación no patológica en la articulación temporomandibular tras recibir estímulos como fuerzas ocasionadas por los tejidos blandos o por la musculatura orofacial circundante[1,2]. Esta teoría postula que existen varias zonas importantes en el crecimiento de la mandíbula que son: el cóndilo, la apófisis coronoides, el cuerpo de la mandíbula, y la zona lingual de la misma[1].

Por otro lado, Enlow trató de explicar el funcionamiento de la aparatología funcional y cómo ésta es capaz de influir sobre el crecimiento mandibular[1]. Determinó que la cantidad de presión aplicada sobre el cóndilo condiciona el crecimiento de la mandíbula, produciéndose un aumento del crecimiento si la presión ejercida es menor, y una reducción si la presión es mayor[1].

Fueron Andresen y Haulp, en 1942, quienes lanzaron la idea de emplear aparatos funcionales con el objetivo de influir sobre el crecimiento del cóndilo para corregir mandíbulas que presentaban un desarrollo incorrecto y lograr un incremento en su desarrollo[1].

Actualmente no existe consenso sobre la edad exacta a la que termina el crecimiento, sin embargo, se determina que existen indicadores tales como la maduración de las vértebras cervicales o de los huesos de la muñeca, que revelan en qué fase del crecimiento se encuentra el paciente[7,8].

Se considera que la estructura craneal completa el 80% de su crecimiento entre los seis y ocho años de edad[8]. Sin embargo, la mandíbula experimenta un gran desarrollo entre los 10 y los 20 años, momento en el que el ortodoncista debe actuar para introducir las modificaciones que estime necesarias según el patrón de crecimiento de la mandíbula[8]. Por otro lado, se determina que existen picos de crecimiento puberal que varían en función del género y la edad[8]. El pico de crecimiento puberal en las niñas se da aproximadamente entre los 10 y 12 años, mientras que en los niños tiene lugar entre los 12 y los 14 años[8].

II. Definición de la maloclusión de Clase II, etiopatogenia y tipos.

La maloclusión clase II se define como un tipo de relación existente entre la arcada superior e inferior, en la que la arcada inferior se encuentra en una posición más distalizada, siendo la referencia para determinarla la cúspide mesio-vestibular del primer molar superior y el surco del primer molar mandibular (Fig.2)[9].

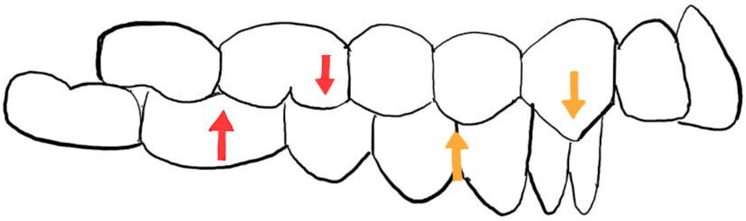

Fig.2. Dibujo de la oclusión de clase II molar y canina. La flecha roja superior señala la cúspide mesiovestibular del primer molar superior y la inferior el surco del primer molar inferior. La flecha naranja superior señala la cúspide del canino superior y la inferior el espacio interproximal entre canino y primer premolar inferior. Ilustración de elaboración propia.

La presente definición fue propuesta por Angle y cabe destacar que únicamente es valorable desde un plano sagital, ya que el autor no tuvo en cuenta otras perspectivas como el plano vertical o el transversal, lo cual supone una limitación en la clasificación[9]. Además, a la hora de realizar la clasificación de las distintas maloclusiones, Angle no hizo referencia a la etiología de las mismas[9].

Existen determinados factores de riesgo que pueden inducir la aparición de una maloclusión de clase II[10]. Estos pueden ser originados antes del nacimiento, como la ingesta de alcohol durante la formación del feto o partos prematuros; o después del nacimiento, como el bajo estatus socio-económico, caries, pérdida temprana de dientes temporales o hábitos orofaciales[10]. Según indica la antropología, se observa una asociación entre una mayor frecuencia de aparición de clases II y el cambio de alimentación que ha experimentado la población a lo largo del tiempo, pasando de una alimentación basada en alimentos duros a una alimentación blanda como la que se tiene actualmente[10]. Esto es debido a que con la alimentación actual se produce un menor desgaste dental y por tanto un menor desplazamiento hacia mesial de los dientes por compensación, lo cual favorece la falta de desarrollo mandibular y por tanto la aparición de las clases II[10].

A su vez, Angle estableció una distinción en las clases II: la clase II división 1 y la clase II división 2, las cuales vienen determinadas principalmente por la relación existente de los incisivos, siendo característico de la división 1 un acusado resalte y proninclinación de los incisivos superiores y de la división 2 una disminución de resalte y retroinclinación de los incisivos superiores (Fig.3)[9,10]. Se determina que la clase II división 1 es más frecuente que la clase II división 2[9,10,11].

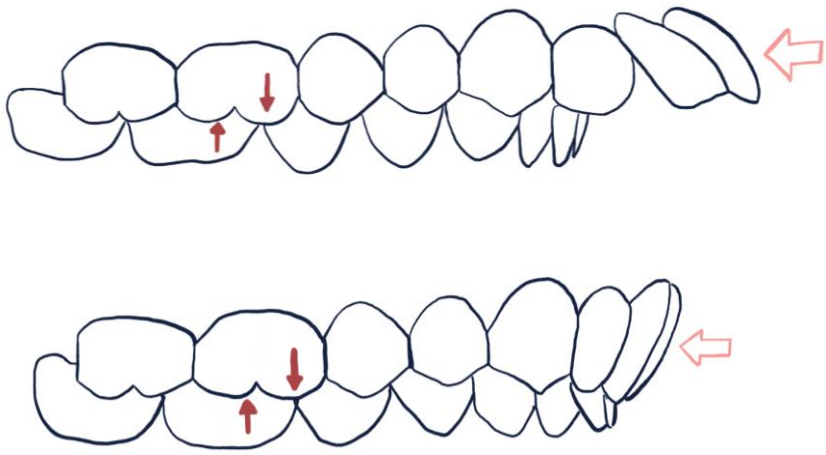

Fig.3. Dibujo de los tipos de maloclusión de Clase II propuestos por Angle. Imagen superior: clase II división 1. Imagen inferior: clase II división 2. Ilustración de elaboración propia.

Es importante destacar que en función del lugar donde se manifieste la maloclusión en mayor medida, se ha de diferenciar entre: clases II esqueléticas, clases II dentoalveolares y clases II dentarias[9].

La maloclusión clase II de origen esquelético es muy común en la población y requiere tratamiento debido a que además de generar problemas funcionales, provoca cambios en la estética facial del paciente, lo cual es una de las principales razones por las que el paciente decide ponerse en manos de un ortodoncista[7,12]. Dicha maloclusión puede tener su origen en el maxilar superior, en la mandíbula o de origen mixto (en ambos maxilares), siendo esta última la más frecuente[9,13].

III. Manifestaciones clínicas de la maloclusión de clase II

La maloclusión de clase II es uno de los problemas más comunes a los que hacen frente los ortodoncistas actualmente, ya que se estima que afecta aproximadamente a un tercio de la población[14,15].

Además, es frecuente encontrar maloclusiones severas de clase II con perfiles retrognáticos muy acusados en síndromes como Pierre Robin, Treacher-Collins, Stickler o Turner[10,16].

En las maloclusiones de clase II se dan diversas alteraciones que varían en función de si el paciente tiene una clase II división 1 o una clase II división 2 y estas alteraciones se pueden manifestar a nivel dentario y/o facial[9,10].

a) A nivel dentario

Se aprecia una distoclusión molar y/o canina, que puede ser bilateral o aparecer en uno de los dos lados, lo que se conoce por "subdivisión"[9,10]. Existen diferencias entre la clase II división 1 y la clase II división 2 (Fig.4)[9,10].

	CLASE II DIVISIÓN 1	CLASE II DIVISIÓN 2
Incisivos superiores	Proinclinación	Retroinclinación
Incisivos inferiores	Angulación normal o proinclinación	Angulación normal o retroinclinación
Resalte	Aumentado	Disminuido
Sobremordida	Normal	Suele estar aumentada

Sonrisa gingival	Poco frecuente	Frecuente
Otros	Mayor tendencia a traumatismos dentales	Mayor incidencia de anomalías dentales. Incisivos laterales o caninos superiores en ocasiones vestibulizados.

Fig.4. Diferencias de las manifestaciones intraorales más frecuentes entre las Clases II división 1 y Clases II división 2[9,10].

Entre las manifestaciones clínicas dentarias más frecuentes en las clases II división 1 se encuentran la proinclinación de incisivos superiores y el resalte aumentado[9,10]. Los incisivos superiores también pueden aparecer con una angulación normal o retroinclinados, así como los incisivos inferiores pueden estar normal o proinclinados[10].

Los pacientes con clases II división 2 presentan una retroinclinación de incisivos superiores, un resalte disminuido, una sobremordida aumentada y los incisivos inferiores pueden presentar una angulación normal o retroinclinada[9,10]. Además, estos pacientes presentan una mayor incidencia de anomalías dentales[10]. En este tipo de clase II es frecuente encontrar una sonrisa gingival debido al gran crecimiento de la apófisis alveolar superior y en ocasiones, los incisivos laterales o los caninos superiores pueden aparecer vestibulizados[9].

La principal diferencia entre las clases II división 1 y 2 se da en la relación que mantienen los incisivos, especialmente determinada por la angulación que presentan los incisivos superiores[9,10].

b) A nivel facial

Las clases II dentarias no deforman al perfil facial, mientras que las esqueléticas pueden producir grandes alteraciones[9]. No obstante, en ocasiones, la clase II de origen esquelético puede quedar enmascarada por los tejidos blandos[9].

La mayoría de los pacientes con maloclusión clase II se caracterizan por presentar una retrusión mandibular o un tamaño mandibular reducido[7,10,15,17]. Como consecuencia, presentan un perfil facial convexo, típico de las clases II división 1, que implican unas proporciones faciales poco estéticas y pobremente aceptadas, así como alteraciones en los tejidos blandos (Fig.5) [9,10,12]. No obstante, en las clases II división 2 aparece una tendencia a un perfil aparentemente cóncavo debido a un incremento de la proyección del mentón por compensación (Fig.6)[9].

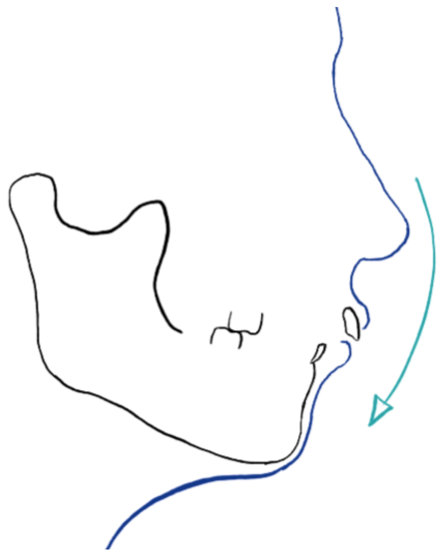

Fig.5. Perfil facial convexo característico de las Clase II división 1. Ilustración de elaboración propia.

Fig.6. "Falso" perfil cóncavo característico de las Clases II división 2. Ilustración de elaboración propia.

Cabe destacar que se observa una relación entre el biotipo facial del paciente y el tipo de maloclusión de clase II que presenta, siendo el patrón dolicofacial característico de las Clase II División 1 y el patrón braquifacial más habitual en las Clase II División 2[10,18].

Con respecto al tipo de labio que presentan estos pacientes, es característico de las clases II división 1 que el labio superior esté situado más próximo al plano estético de Rickets, sea más corto de lo habitual, hipotónico y con poca capacidad de ejercer presión sobre los incisivos superiores, lo cual dificulta la compensación de la proinclinación que presentan y suponen una falta de sellado labial[10,19]. Sin embargo, en las clases II división 2 es frecuente encontrar un labio más grueso y más competente, que ejerce una mayor presión y por tanto está asociado con la retroinclinación de los incisivos superiores[10,19].

Es importante resaltar que existen una serie de hábitos asociados a la aparición de maloclusiones de clase II que en ocasiones pueden ser corregidos con aparatología funcional pero en determinados casos estará indicado combinar la aparatología con una terapia miofuncional, propuesta en los inicios por Rogers, para actuar directamente sobre la musculatura y corregir de esta manera diversos hábitos orofaciales que dificultan el tratamiento de la maloclusión[9,20,21]. Son muy comunes la succión digital, la interposición labial inferior, la deglución atípica o la respiración oral[9].

IV. Aparatología funcional

La aparatología funcional comenzó a usarse por primera vez en la década de los 80´ y consiste en un conjunto de dispositivos que surgen de la necesidad de corregir las maloclusiones de clase II y actúan transmitiendo fuerzas originadas por la musculatura tanto a la dentición como a las bases óseas[20].

El mecanismo de acción de los aparatos funcionales para clases II consiste fundamentalmente en actuar sobre la musculatura generando diferentes tipos de fuerzas que mantengan la mandíbula en una posición más avanzada[9].

Entre estas, destacan las fuerzas fisiológicas que son aquellas fuerzas de intensidad ligera que se generan cuando el aparato actúa directamente sobre la musculatura, alterándola y deformándola de manera que se crean unas presiones que a continuación son transmitidas a las bases óseas y a los dientes[9]. Por otro lado, las fuerzas funcionales que se producen son de tres tipos: las musculares, que actúan directamente sobre los músculos orofaciales; las oclusales, ejercidas por el acrílico interpuesto entre la arcada superior e inferior que hace que engranen los dientes de arriba y de abajo en una nueva posición en la que la mandíbula se encuentra más avanzada; y las fuerzas que liberan presiones del ambiente, es decir, liberan las fuerzas generadas por estructuras como la lengua, los labios o las mejillas que son circundantes a los dientes, los cuales están situados en el conocido "Pasillo de Tomes", y que condicionan su posicionamiento[9].

Los aparatos funcionales tienen otra función que consiste en guiar el movimiento de erupción de los dientes en función de las necesidades terapéuticas[9]. Es decir, realizando modificaciones sobre el acrílico del aparato se puede tener un control de estos movimientos de tal forma que si se coloca el acrílico en contacto con la cara oclusal del diente se limita su erupción, y si se interpone el acrílico evitando el contacto, el diente erupcionará más buscando el contacto con el mismo[9,22].

A pesar de existir diferentes tipos de aparatos funcionales, la mayoría tienen en común que son principalmente rígidos y que son efectivos posicionados en boca de manera fundamentalmente pasiva, pudiendo ser fijos o removibles[9,21,20].

La función principal de la aparatología funcional de clases II es estimular el crecimiento mandibular[13,15,21,23,24].

Estos dispositivos, deben usarse a lo largo de la etapa del crecimiento puberal del paciente para obtener la máxima eficacia en los resultados[8,20,22]. La verdadera indicación de la aparatología funcional es en clases II de origen esquelético con retrognatismo mandibular, es decir, en pacientes que presentan una falta de desarrollo mandibular y que se encuentran en crecimiento[8,13,20].

Para la fabricación de los mismos es imprescindible la realización de una mordida constructiva, que consiste en registrar mediante ceras la nueva posición mandibular que se quiere lograr durante el tiempo que el aparato esté colocado en boca[25,26,27]. Esta posición, en caso de las maloclusiones de clase II, será adelantada[25,26].

En 1880, Kingsley introduce por primera vez el concepto de adelantar la mandíbula en pacientes con una mandíbula retrognática, presentando el dispositivo **"Bite-Jumping"**[21,28]. Su diseño se basa en una placa maxilar de tipo removible con sujeción en los molares, un arco vestibular continuo y un plano de mordida inclinado que provocaba un salto en la mordida, y supuso la base de los diseños futuros de aparatos funcionales cuyo objeto era producir un avance mandibular[21].

En 1902, Pierre Robin introdujo un nuevo dispositivo denominado **"Monoblock"**, cuyo mecanismo de acción consistía en cambiar la relación entre el maxilar y la mandíbula, provocando una nueva adaptación de la musculatura[21]. Su diseño consiste en un único bloque con huellas interoclusales, cuya extensión cubría las superficies linguales de todos los dientes y con un tornillo de expansión en su interior[21].

En 1938 aparece el **Activador,** diseñado por **Andresen** y propulsado por HÄulp, quienes lanzaron el concepto de aparatología funcional en Europa[21,28]. El diseño original del mismo consistía en una modificación del “Monoblock de Robin”, siendo un único bloque de acrílico de ajuste pasivo, cuya extensión cubre el paladar y los dientes de ambas arcadas, siendo el acrílico interpuesto entre ambas de espesor variable en función de la mordida constructiva, y un arco vestibular superior y otro inferior (Fig.7)[21,28,29].

Fig. 7. Activador de Andreasen. 1) arco vestibular superior, 2) monobloque de acrílico[29].

Su mecanismo de acción consiste en provocar el estiramiento de los músculos elevadores de la mandíbula y tejidos blandos, originando el reflejo miotático, de forma que se produzcan contracciones en la musculatura orofacial, lo cual induce a un crecimiento de la mandíbula hacia delante y hacia abajo[28]. Otro de sus efectos es la aparición de una ligera apertura en la mordida de aproximadamente 3-4 milímetros[21]. Es un diseño de escasa complejidad, capaz de producir cambios en los tres planos del espacio, que presenta determinadas ventajas y desventajas (Fig.8)[21,28].

VENTAJAS	**DESVENTAJAS**
Permite el tratamiento en distintas fases de dentición temporal o mixta	El éxito del tratamiento depende del grado de colaboración del paciente

No daña tejidos colindantes	No existe buena respuesta al tratamiento en edades avanzadas
No altera en exceso la estética facial	Complejo control preciso de las fuerzas que inciden en cada diente
Posibilita una buena higiene	--
Capaz de corregir hábitos orofaciales	--

Fig.8. Ventajas y Desventajas del Activador de Andreasen[21].

Klammt presenta una modificación del activador tradicional llamado **Activador Abierto Elástico de Klammt**, empleado para corregir maloclusiones clase II y para la corrección de hábitos, en la que se recortó parte del acrílico anterior aportando una mayor comodidad al paciente, los arcos vestibulares se extendieron hacia los sectores posteriores y se introdujeron elementos nuevos como un resorte de Coffin en el paladar para lograr expansión y resortes linguales (Fig.9)[29].

Fig.9. Activador Abierto Elástico de Klammt. 1) Resorte de Coffin, 2) arcos vestibulares, 3) resortes linguales para dientes anterosuperiores e inferiores[29].

En 1960, **Balters** presentó un nuevo diseño del activador denominado **Bionator**[9,21,30]. Este dispositivo ha ido sufriendo modificaciones con el paso del tiempo pero el Bionator estándar está compuesto por un único bloque de acrílico adaptado a todas las caras linguales de los dientes superiores e inferiores así como a las caras oclusales; alambres de acero inoxidable de 0,9mm; un arco vestibular, dos asas buccinadoras que eliminan la presión muscular ejercida por las mejillas, y un resorte Coffin en el paladar (Fig.10)[21,29].

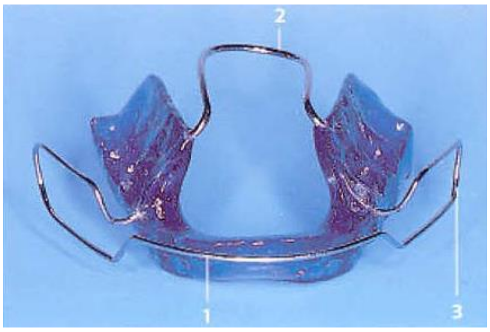

Fig.10. Bionator de Balters. 1) Arco vestibular, 2) Resorte de Coffin, 3) asas buccinadoras[29].

Es un aparato pasivo, que produce efectos a nivel esquelético en la mandíbula, provocando su anterorrotación, aumento de longitud y consiguiente avance mandibular, y a nivel dentoalveolar tanto en la mandíbula como en el maxilar[23,30].

Una de sus funciones principales reside en la actuación sobre la musculatura orofacial del paciente, ya que las asas buccinadoras liberan la presión ejercida por el buccinador y dispone de un arco vestibular situado en la zona anterior que crea una presión negativa, la cual favorece al sellado labial y además da lugar a un reposicionamiento más anterior-inferior de la lengua, que a su vez favorece la proinclinación de incisivos inferiores y el crecimiento mandibular, es decir, crea un nuevo patrón neuromuscular capaz de corregir la maloclusión de clase II con resultados eficaces tanto a corto como a largo plazo (Fig.11)[30,29].

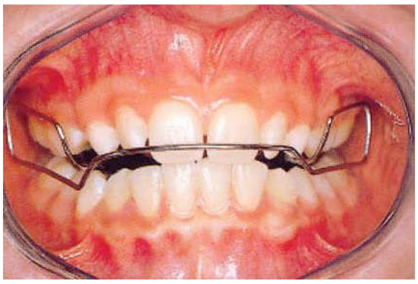

Fig.11. Bionator de Balters. Vista intrabucal desde un plano frontal[29].

Una nueva variante del activador, el **Modelador Elástico de Bimler**, fue presentado por Bimler[9]. Consiste en un aparato funcional bioelástico cuyo mecanismo de acción también consiste en la aplicación de fuerzas neuromusculares que son transmitidas a los dientes y el control de movimientos eruptivos pero, a diferencia del resto, además de lograr una protrusión mandibular es capaz de producir una expansión trasversal[21,31]. Lo característico de su diseño consiste en un tamaño más reducido, con menor cantidad de acrílico, lo cual dota al aparato de una mayor elasticidad y por lo tanto con mayor capacidad de producir movimientos eficaces en la dentición[21]. Existen diversas variantes para tratar las clases II: el Bimler tipo "A", especialmente indicado para las de división 1, y el Bimler tipo "B" para las de división 2 (Fig.12)[32].

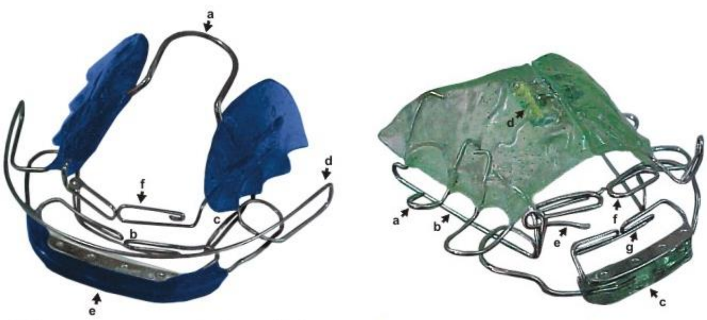

Fig.12. Aparato de la izquierda Bimler tipo "A" (azul). Aparato de la derecha Bimler tipo "B" (verde)[32].

Otro aparato funcional presentado por **Fränkel** en 1957, es el **Regulador funcional**[21,26]. Este dispositivo es capaz de corregir diferentes maloclusiones sin tener contacto con los dientes[21]. Existen cuatro modalidades del aparato capaces de corregir diferentes maloclusiones: Frankel I para corregir maloclusiones de clase I; Frankel II para clases II división 1 y 2 (Fig.13); Frankel III para corregir maloclusiones de clase III y Frankel IV para la corrección de mordidas abiertas[26,29].

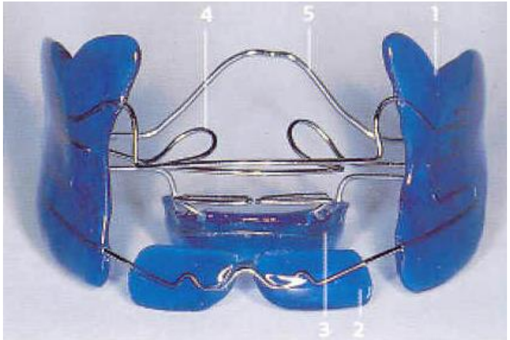

Fig.13. Frankel tipo II para maloclusiones de clase II. 1) Acrílico bucal, 2) pantallas labiales inferiores, 3) arco lingual, 4) resortes palatinos, 5) arco de expansión[29].

El Frankel II es un aparato con un diseño de cierta complejidad cuya acción principal consiste en eliminar la presión que ejerce la musculatura sobre el vestíbulo oral, impidiendo el desarrollo correcto de las bases óseas[21,26]. Entre los efectos de este dispositivo destacan: la inhibición de la acción muscular de músculos como los buccinadores o el músculo mentoniano, favoreciendo el crecimiento mandibular y corrigiendo la maloclusión clase II; la expansión dentoalveolar a nivel del maxilar; la aparición del surco mentolabial menos marcado y un favorece un buen sellado labial[26].

Está compuesto por dos escudos buccinadores y dos paralabios de acrílico (Fig.14) y seis elementos de alambre de acero inoxidable de 0,9 milímetros que son: dos arcos superiores, uno por vestibular y otro por lingual para evitar la inclinación de los incisivos maxilares; asas a nivel de los caninos superiores; un alambre transpalatino; un arco lingual con alambres cruzados en forma de escudo detrás de los incisivos inferiores; y un alambre en el fondo de vetíbulo antero-inferior para sostener el paralabios (Fig.15)[26,32].

Fig.14. Frankel II sobre modelo de escayola donde se aprecian los escudos buccinadores y paralabios[32].

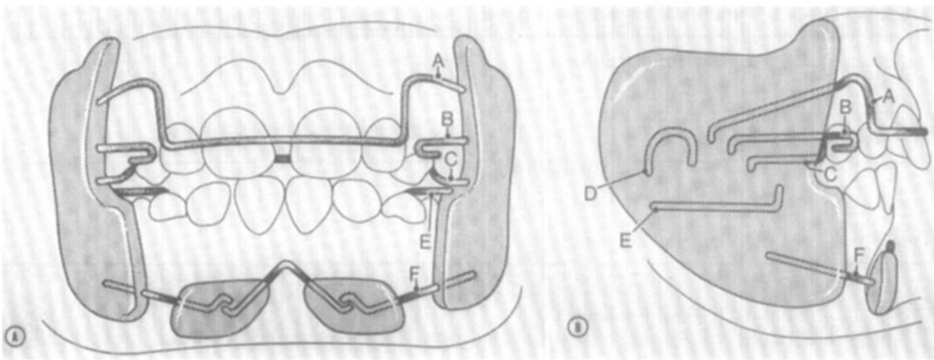

Fig.15. Dibujo del diseño original del aparato de Frankel tipo II. A) Arco vestibular superior, B) extensiones hacia caninos, C) Arco lingual, D) arco de expansión del paladar, E) resortes linguales, F) pantallas vestibulares labiales inferiores[26].

A finales de la década de 1980, **Clark** presentó el aparato funcional removible denominado **Twin-block**[27,33]. El diseño del mismo consiste en dos bloques independientes, uno superior y otro inferior, que al ocluir contactan en un plano que presenta una inclinación de 45 grados, lo que obliga a la mandíbula a situarse en una posición más adelantada (Fig.16)[27,34,35].

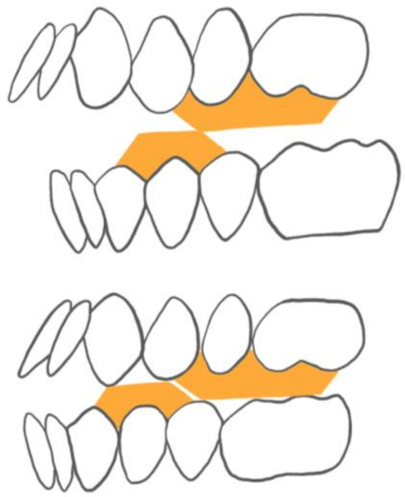

Fig.16. Ilustración de los dos bloques del aparato funcional Twin Block desde una vista lateral. Ilustración de elaboración propia.

El diseño inicial del dispositivo superior del Twin Block está compuesto por acrílico que cubre únicamente las cúspides linguales superiores, un arco vestibular de alambre para regular la inclinación de los incisivos, tubos en forma de coil de anclaje extraoral por si fuera necesaria la tracción maxilar, un tornillo de expansión para expandir el maxilar, dos ganchos en C en distal de los incisivos laterales, ganchos de bola y ganchos de Adams en los molares definitivos[27]. Por otro lado, el diseño original del dispositivo inferior consiste en un aparato de acrílico que se extiende sobre la totalidad de las caras oclusales inferiores con límite posterior en los premolares, ganchos tipo delta fabricados con alambre en el sector anteroinferior para evitar inclinaciones incisales no deseadas, y ganchos en los premolares inferiores (Fig.17)[27,34].

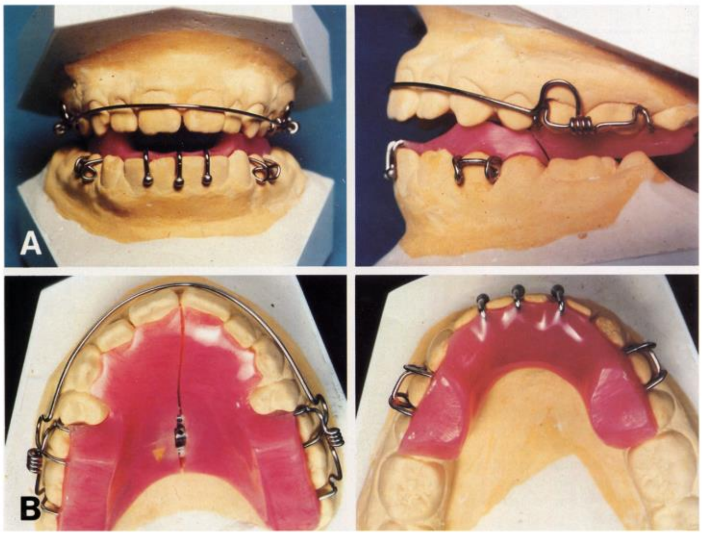

Fig.17. Diseño original en cera del aparato Twin Block presentado en 1988 por W.J. Clark. A) Vista frontal y lateral, B) Vista oclusal superior e inferior [34].

No obstante, este diseño original ha ido variando e incorporando modificaciones a lo largo del tiempo en función de las necesidades terapéuticas (Fig.18)[24,35].

Fig.18. Modificación del Twin Block empleada en la actualidad [35].

Además, este dispositivo aporta una mayor comodidad al paciente debido a que permite la realización de los movimientos excursivos de la mandíbula como lateralidad o protrusión y no dificulta en exceso la fonación[34,35].

El aparato Twin Block produce efectos tanto a nivel esquelético como dentoalveolar [24,36]. Entre los efectos esqueléticos destacan la mejora de la relación intermaxilar desde un plano sagital debido al avance mandibular que se produce al eliminar la presión ejercida por la musculatura orofacial y tejidos blandos colindantes y un aumento de la longitud de la mandíbula[24,36]. A nivel dentoalveolar, produce una retroinclinación de los incisivos superiores debido a la presencia del arco vestibular y una proinclinación de los incisivos inferiores, ocasionando una disminución del resalte[24]. Por otro lado, mejora el perfil facial bando de los pacientes con maloclusiones de clase II, reduciendo la convexidad facial debido a la reducción de la protrusión del labio superior característica de las clases II división 1 al corregir la inclinación de los incisivos; y al avance mandibular que desplaza a los tejidos blandos inferiores hacia delante, aportando una mayor armonía a la estética facial del paciente[24,22].

En 1905 **Herbst** introduce un aparato funcional fijo que garantiza la colaboración de los pacientes ya que está presente en boca 24 horas al día y no puede ser removido por parte del paciente[6,21]. Inicialmente, no resultó muy exitoso hasta que años más tarde, en 1979, Pancherz retomó su uso[25,37].

El aparato de Herbst produce modificaciones en el crecimiento condiliar y en la cavidad glenoidea, y sitúa a la mandíbula permanentemente en una posición más adelantada, de forma que logra la corrección de las clases II[6,21,37,38]. A nivel esquelético, produce un avance mandibular[37]. Entre los efectos que produce a nivel dentario y facial, destaca en el plano sagital la reducción de la convexidad facial, la distalización de la arcada superior, mesialización de la arcada inferior y la proinclinación de los incisivos inferiores[6,39].

El diseño del Herbst clásico se basa en un sistema telescópico de tubo-émbolo, cuyos componentes principales son unos tornillos soldados a bandas cementadas en los molares permanentes, un émbolo (pin o tubo) y unos aditamentos que fuerzan una posición mandibular adelantada (Fig.19)[21,25,37].

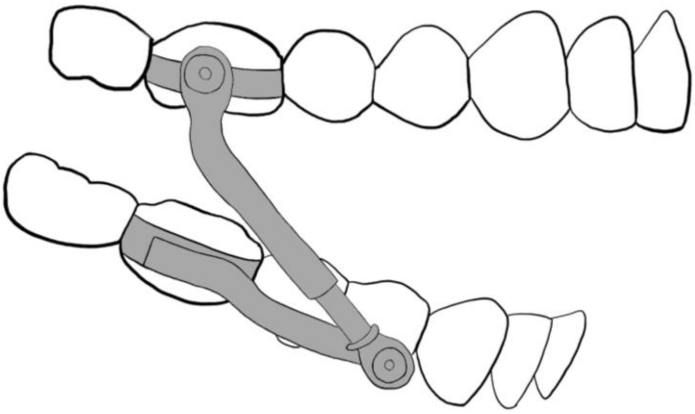

Fig.19. Dibujo del sistema de tubo-émbolo del aparato de Herbst soldado a bandas desde una vista lateral. Ilustración de elaboración propia.

Con el paso del tiempo este diseño ha ido experimentando variaciones como una cementación mediante coronas metálicas de acero inoxidable en lugar de bandas, o la aparición del Herbst con férulas acrílicas situadas en la arcada superior e inferior[25,37]. Estas férulas pueden ser fijas o removibles, siendo preferible las de tipo removible debido a que se reduce el riesgo de aparición de caries existente cuando el dispositivo está cementado[25].

El aparato de Herbst presenta algunas limitaciones como son la rigidez, gran riesgo de fractura y complejo proceso de fabricacion en el laboratorio, lo que conlleva a la aparición de un nuevo aparato funcional fijo llamado **Forsus™ Fatigue Resistant**, ideado por la casa comercial 3M®[13,40]. A diferencia del anterior, este dispositivo es semirrígido y su diseño se basa en un muelle de tamaño estándar que es introducido en el tubo vestibular del primer molar maxilar y anclado al arco inferior mediante una biela, que puede ser de diferentes tamaños, el cual puede ser activado por la acción de unos aditamentos que se crimpan o ajustan al aparato tras ser apretados (Fig.20)[40,41]. Produce efectos tanto a nivel esquelético como dentoalveolar, entre los que destacan: un reposicionamiento anterior de la mandíbula y aumento de su longitud; aumento de la longitud de la rama mandibular; intrusion y proinclinación de incisivos inferiores; distalización de molares superiores y mesialización del arco dentario inferior[13,41].

Fig.20. Forsus™ Fatigue Resistant combinado con aparatología fija multibracket[13].

OBJETIVOS

- **Objetivo principal:** Estudiar las diferentes alternativas terapéuticas existentes para el tratamiento de las maloclusiones de clase II con aparatología funcional.
- **Objetivos secundarios:**

- Determinar los factores a tener en cuenta en la elección del aparato funcional de clase II.
- Evaluar los efectos que provocan los mismos en el crecimiento mandibular, a nivel dentoalveolar y en el maxilar superior.
- Establecer los principios generales y manejo clínico de la aparatología funcional de clases II.
- Determinar cómo mejorar la práctica clínica diaria de los tratamientos con aparatología funcional removible de clase II.

MATERIALES Y MÉTODOS

Para la ejecución de la presente revisión bibliográfica se realizó una búsqueda avanzada de artículos científicos en las bases de datos digitales: *PubMed, Medline Complete, Academic Search Ultimate y Google Scholar,* a las que se accedió a través de la Biblioteca Virtual de la Universidad Europea de Madrid. Las palabras clave que se utilizaron para realizar la búsqueda bibliográfica fueron: "orthodontics", "orthopedics", "malocclusions", *"class II malocclusion", "functional appliances", "mandibular growth", "removable appliance", "fixed appliance".*

Para acotar la búsqueda y seleccionar los artículos se aplicaron los siguientes criterios de exclusión y de inclusión.

Criterios de exclusión: (*)

- Artículos no relacionados con la temática principal de la presente revisión bibliográfica.
- Artículos cuyas conclusiones no hicieran referencia a los objetivos de la presente revisión bibliográfica.
- Artículos escritos en un idioma que no fuera inglés o español.
- Artículos no publicados en revistas de alto impacto.
- Artículos no presentes en las bases de datos anteriormente mencionadas.

Criterios de inclusión:

- Artículos relacionados con la temática principal de la presente revisión bibliográfica.

- Artículos cuyas conclusiones hicieran referencia a los objetivos de la presente revisión bibliográfica.
- Artículos escritos en inglés o español.
- Artículos publicados en revistas de alto impacto.
- Artículos presentes en las bases de datos anteriormente mencionadas.

Se seleccionaron 54 artículos publicados en revistas de alto impacto como *“European Journal of Dentistry”, “American Journal of Orthodontics & Dentofacial Orthopedics”,* “Journal of Oral Rehabilitation”, “American Academy of Gnathologic Orthopedics” y “Revista Española de Ortodoncia”.

La mayor parte de los artículos seleccionados fueron publicados en los últimos 10 años. Los artículos seleccionados con fechas de publicación anteriores fueron los artículos originales en los que el autor presentó el aparato en cuestión y cuya información de gran relevancia no se encontró en publicaciones posteriores.

Por otro lado, se consultaron 2 libros de ortodoncia: “*Ortodoncia y cirugía ortognática diagnóstico y planificación” de Jorge Gregoret,* y *“Ortodoncia Clínica y Terapaéutica” de José Antonio Canut Brusola;* y otros dos para la obtención de imágenes: *“Aparatología en Ortopedia Funcional”* de Ulrike Grohmann y *“Atlas de Aparatología Funcional y Aparatología Auxiliar”* de Juan Carlos Velarde Yositomi.

RESULTADOS

El siguiente diagrama refleja los resultados de la búsqueda bibliográfica avanzada llevada a cabo para realizar la presente revisión de la literatura, en el que se muestra el número de artículos que aparecieron en cada base de datos mediante el uso de las palabras clave “class II”, “malocclusion” and “functional appliances”; así como el método de selección de los artículos en los que finalmente se basó la presente revisión bibliográfica (Fig.21). Se seleccionó la opción “texto completo disponible”.

Los resultados de la búsqueda avanzada fueron los siguientes:

PubMed	***Medline Complete***	***Academic Search Ultimate***	***Google Scholar***
199	509	49	287

1044 artículos fue el resultado total de la búsqueda

Aplicación de criterios de exclusión y de inclusión. (*)

Lectura de títulos y abstracts para proceder a la selección de artículos relevantes.

***54 artículos** fueron seleccionados*

Fig.21*. Proceso de selección de la bibliografía empleada para la realización de la presente revisión bibliográfica.*

Durante el proceso de realización de la presente revisión bibliográfica, se emplearon otras palabras clave como “Andreasen activator” “Monoblock”, “Bimler”, “Bionator”, "Frankel", "Twin Block", "Forsus", "Herbst" en las bases de datos anteriormente mencionadas y en revistas de alto impacto como *"European Journal of Dentistry", "American Journal of Orthodontics & Dentofacial Orthopedics",* para proceder a la selección de artículos más específicos.

DISCUSIÓN.

Existe un acuerdo generalizado entre los autores en la idea de que la aparatología funcional es capaz de lograr la corrección de las maloclusiones de clases II en determinadas ocasiones, estimulando el avance mandibular[6,8,17,23]. El uso a tiempo de aparatología funcional puede incluso evitar futuras extracciones en fases más avanzadas del tratamiento[22]. No obstante, para lograr el éxito terapéutico la colaboración del paciente es fundamental, especialmente si se trata de aparatología de tipo removible[21,39].

Autores como Chaudry et al, Wahl et al, o Baysal et al coinciden en que la principal ventaja de la aparatología funcional fija con respecto a la removible reside en la disminución de la dependencia de cooperación y participación por parte del paciente durante el tratamiento, y confirman que mediante el uso de estos dispositivos fijos es probable una duración del tratamiento menor y por tanto serán de elección en pacientes poco colaboradores[21,39,42]. Además, el empleo de aparatología funcional fija favorece un mayor avance mandibular gracias a la acción de fuerzas de forma continuada, según lo propuesto por Megan LeCornu et al en su estudio de 2013[43]. Otros autores como Vela-Hernández et al coinciden con la idea anteriormente mencionada pero destacan que se pueden lograr efectos muy similares tanto con aparatología funcional fija como removible, a pesar de presentar ligeras diferencias como el alcance de una mayor proinclinación de incisivos inferiores con la aparatología funcional removible que con la fija[44].

Se aprecian diferencias entre los autores con respecto al manejo clínico y efectos terapéuticos a nivel dentario y a nivel esquelético de los distintos aparatos funcionales [17].

Se determina que el Bionator no produce efectos a nivel esquelético en el maxilar superior, pero sí estimula el crecimiento en la mandíbula, además de producir efectos dentoalveolares en ambos maxilares[23,30,45]. Almeida et al destacan en su estudio la retroinclinación de los incisivos superiores y proinclinación de los incisivos inferiores como dos de los principales efectos dentoalveolares del dispositivo, lo cual es ideal para el tratamiento de maloclusiones de clase II división 1[23]. Sin embargo, Bigliazzi et al (2015) reportan la ausencia de cambios notables en la inclinación de incisivos inferiores (Fig.22)[30]. Por otro lado, Almeida et al afirman que este dispositivo produce una ligera extrusión de los molares inferiores, mientras que en el maxilar no se observa extrusión molar superior ni produce ningún efecto esquelético[23]. Ambos autores coinciden en que los mayores efectos de este dispositivo se producen a nivel dentoalveolar, siendo el más significativo la retrusión de los incisivos superiores corrigiendo la sobremordida y el resalte, sin alterar el patrón de crecimiento craneofacial del paciente, es decir, sin alterar significativamente la dimensión vertical[23,30].

Fig.22. Bionator posicionado en boca desde una vista lateral derecha, frontal y lateral izquierda[30].

Numerosos expertos muestran acuerdo en que el uso de los aparatos funcionales mejora considerablemente el perfil facial del paciente (Fig. 23), favoreciendo el correcto sellado labial y reposicionando la lengua en una posición más fisiológica[22,23,30,38].

Fig.23. Telerradiografía pre-tratamiento (izquierda) y post-tratamiento (derecha) con aparato de Twin Block donde se observa una mejora del perfil facial[22].

Sin embargo, en la revisión sistemática llevada a cabo por Flores-Mir y Major et al se establece la falta de evidencia de la mejora del perfil facial en pacientes con clase II tras el tratamiento con algunos aparatos funcionales como el Twin Block[46]. Asimismo, Tsiouli et al (2017) sugieren una ligera mejora del perfil reduciendo la convexidad facial tras el tratamiento con aparatos funcionales pero esta presenta ciertas limitaciones y los ortodoncistas deber ser cautos a la hora de predecir estos cambios en la estética facial de los pacientes[47]. En dicho estudio se concluye que tras la terapia con el Activador o Twin Block los mayores cambios percibidos se dan en el tercio inferior a la altura del mentón sin existir grandes diferencias entre ambos, y la mejora del perfil y de la posición del labio superior es ligeramente más notable tras la terapia con el Twin Block que con el Activador[47].

Lee et al reportan en su investigación de 2016 que los dos dispositivos funcionales más utilizados para corregir las maloclusiones de clase II son el Twin Block y el Forsus™ Fatigue Resistant, siendo el primero el que actúa con mayor eficacia a nivel esquelético debido a la producción de un mayor avance y estimulación del crecimiento de la mandíbula gracias a un cambio en la dirección del crecimiento del cóndilo más posterior, siendo este el factor más importante, y cambios en la rama mandibular[22]. Del mismo modo, Doshi et al en 2014 confirman la efectividad del Twin Block en términos de avance mandibular (Fig.24)[48]. No obstante, Ortu et al en 2019 demuestran la capacidad de otros dispositivos funcionales removibles como el Bimler en la corrección de clases II, especialmente división 1, mediante la creación de un nuevo patrón neuromuscular más fisiológico, que favorece el crecimiento de la mandíbula[31].

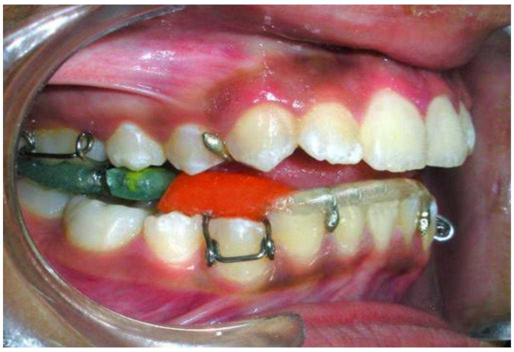

Fig.24. Modificación del aparato de Twin Block, vista intraoral[48].

Asimismo, Perillo et al confirman en su meta-análisis de 2011 la capacidad del Frankel II de corregir maloclusiones de clase II gracias a la estimulación del crecimiento mandibular y Ulrike et al aseguran que el Activador Abierto Elástico de Klammt puede ser empleado en todos los tipos de maloclusiones de clase II propuestas por Angle[17,29].

Se aprecia controversia entre los autores con respecto a los efectos que ocasiona la aparatología funcional de clase II en el maxilar superior. *Christine M Mills et al* y Singh et al (2012), afirman que el Twin Block produce una ligera disminución y restricción del crecimiento del maxilar superior, mientras que autores como Keun Young Lee et al (2016) o Baysal et al (2014) aseguran que los efectos a nivel esquelético de este dispositivo se limitan a potenciar el crecimiento de la mandíbula, sin ocasionar cambios en el maxilar superior[22,36,39,45,49].

Sin embargo, en la revisión sistemática de Xin Yang (2016) o en el estudio de Megan LeCornu et al, se determina que dispositivos funcionales como el aparato de Herbst, además de producir un avance mandibular, frenan el crecimiento del maxilar superior[37,43]. A diferencia de lo reportado por Amuk et al (2019), donde se establece que no se aprecian cambios importantes en el crecimiento del maxilar superior tras el uso de este aparato[38]. Por otro lado, en el estudio original realizado por Pancherz a veinte individuos en crecimiento con maloclusiones de clase II tratados con Herbst durante un periodo de 6 meses, se determinó la efectividad del mismo tanto en la mandíbula ocasionando su avance, como en el maxilar restringiendo su crecimiento, coincidiendo con lo propuesto por Xin Yang et al en 2016[6,37].

En 2014 Baysal y Uysal et al evalúan y comparan los efectos que producen el aparato de Herbst y el Twin Block en individuos de 12-13 años de edad que presentaban clase II división 1 con retrusión mandibular[39]. Afirman que el Twin Block actúa fundamentalmente a nivel esquelético estimulando el avance mandibular y por tanto está especialmente indicado en pacientes que presentan retrognatismo mandibular; mientras que el Herbst tiene efectos esqueléticos y dentoalveolares como la distalización de la arcada superior y protrusión del sector anterior de la arcada inferior, por lo que su principal indicación son pacientes con clase II esquelética que presenten incisivos superiores protruidos e inferiores retruidos[39]. Pancherz et al y Wahl et al señalan que el Herbst está especialmente indicado en pacientes con clases II severas con una mandíbula retrognática e incisivos mandibulares retroinclinados que se encuentran en la última etapa de su crecimiento y que sean poco colaboradores con el tratamiento al tratarse de una opción fija[6,21].

Por tanto, los resultados de varios estudios muestran que el Twin Block corrige maloclusiones de clase II produciendo principalmente cambios a nivel esquelético en la mandíbula con mayor eficacia que el resto de dispositivos funcionales, mientras que el Herbst corrige maloclusiones de clase II ocasionando cambios fundamentalmente a nivel dentario[37,39]. No obstante, en el estudio de Singh et al (2012) se demuestra que el Twin Block también produce efectos dentoalveolares destacando la linguoversión de incisivos superiores y vestibuloversión de incisivos inferiores, logrando una gran disminución del resalte[49].

Los efectos esqueléticos y dentoalveolares del Twin Block y del Bionator en las maloclusiones de clase II, fueron comparados por Jena y Duggal et al[45]. Evaluaron a 55 niñas con retrognacia mandibular situadas en la misma etapa de crecimiento, donde unas fueron tratadas con Twin Block y otras con Bionator, y se concluyó que ambos dispositivos eran efectivos en la corrección de la maloclusión y mejora de la relación incisal, resultando más efectivo el Twin Block que el Bionator[45]. Se logró un mayor avance mandibular en las pacientes tratadas con Twin block (5,02mm) que con Bionator (4,42mm)[45].

En las maloclusiones de clase II división 2, profesionales como Condò et al (2010), Bayram et al (2017) o Partal et al (2017) reportan la necesidad de una primera fase de tratamiento en la que se debe “convertir” la clase II división 2 en una clase II división 1, protruyendo los incisivos superiores (Fig.25) (Fig.26)[41,50,51].

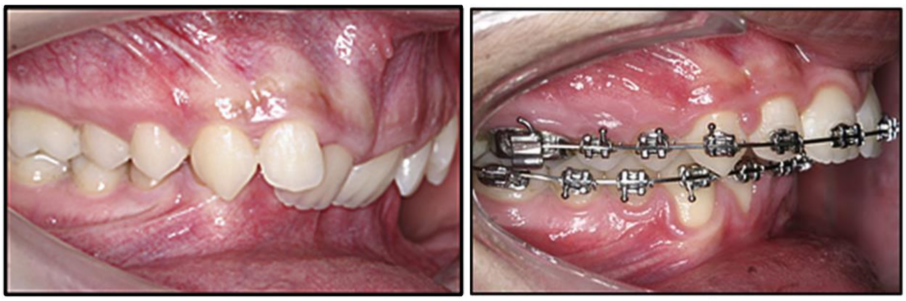

Fig.25. Fase inicial antes de iniciar el tratamiento con aparatología funcional para “convertir” la clase II división 2 en una clase II división 1[41].

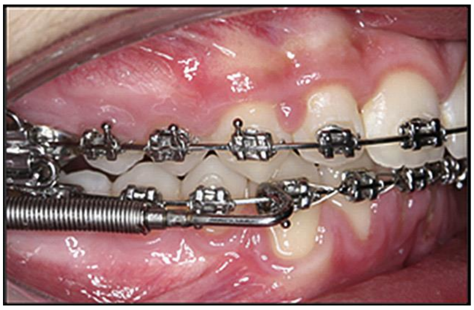

Fig.26. Terminada la fase inicial, inicio de tratamiento funcional con Forsus™ asociado a aparatología fija multibracket[41].

Bayram et al demuestran la efectividad del Forsus™ Fatigue Resistant en adolescentes tanto con maloclusión de clase II división 2 como clase II división 1[41]. Sin embargo, Asensi aconseja que el uso de este dispositivo debe limitarse al tratamiento de las maloclusiones de clase II división 1[40]. Por otro lado, Clark afirma que el aparato Twin Block puede ser empleado para la corrección de las clases II división 2 con un diseño que permita la vestibuloversión de incisivos superiores mientras que Condò et al en 2010 sugieren que si estas maloclusiones son tratadas con Twin Block se requiere de una segunda fase para lograr el correcto engranaje y alineamiento de ambas arcadas[34,51].

Los autores coinciden en que, en ocasiones, para lograr la corrección de la maloclusión y realizar un tratamiento ortodóncico más completo, es necesario complementar la terapia funcional con otros tratamientos ortodóncicos[25,41,52]. McNamara et al señalan que el aparato de Herbst con férulas puede emplearse junto con otros elementos para lograr la expansión del maxilar superior como un disyuntor, un omega en el paladar o aparatología fija multi-bracket para corregir malposiciones dentarias y alcanzar los objetivos deseados del tratamiento[25,52]. Del mismo modo, Bayram et al indican que junto a la ayuda de aparatología fija multibracket, el Forsus™ Fatigue Resistant es capaz de lograr la mejora del perfil facial del paciente y la corrección de la maloclusión[41].

Existen distintas opiniones en la determinación del momento ideal para iniciar la terapia con el Twin Block[22,36]. Algunos expertos indican que el mejor momento para iniciar el tratamiento se da en la adolescencia, durante el pico de crecimiento puberal que varía en función del sexo, debido a que en ese momento se ha observado que se alcanzan resultados óptimos de avance mandibular (Fig.27)[22].

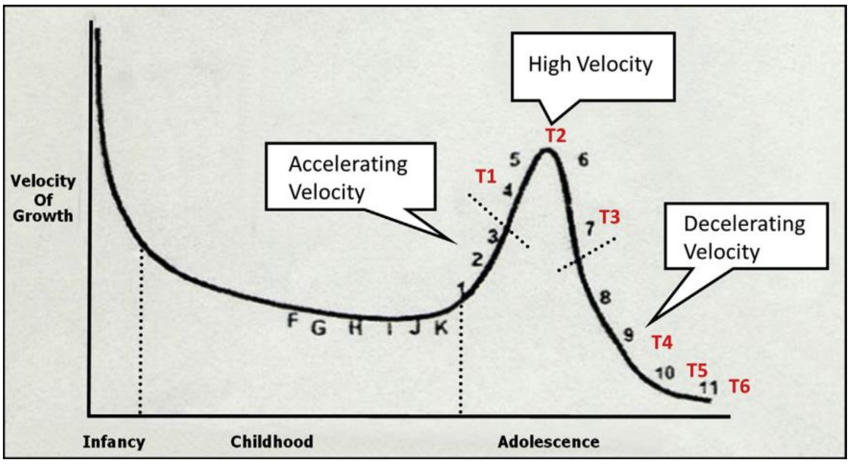

Fig.27. Representación de la velocidad de crecimiento hasta la adolescencia, donde se observa el pico de crecimiento puberal[22].

Sin embargo, Mills y McCulloch et al determinan que el mejor momento para iniciar la terapia es durante la fase de dentición mixta ya que el diseño del aparato se adapta mejor sobre molares temporales, los pacientes de menor edad se adaptan mejor a los aparatos removibles debido a que se generan menos alteraciones en la fonación y los familiares se muestran más involucrados y con una participación más activa en el tratamiento que una vez alcanzada la adolescencia[36]. Singh et al concluyen que este dispositivo puede ser empleado tanto al inicio como al final de la fase de dentición mixta, siendo aconsejable iniciar el tratamiento de las clases II al comienzo de la misma debido a que gracias al tratamiento se logra una mejora de la estética facial del paciente y con ello una mejora de su autoestima[49]. Otra ventaja de iniciar el tratamiento en una fase temprana es la disminución del riesgo de sufrir un trauma en los incisivos superiores en pacientes con clase II división 1[49].

Autores como Aynur Aras et al reportan en su investigación la ausencia de cambios mandibulares estadísticamente significativos en los casos en los que el Forsus™ fue empleado tras haber finalizado el pico de crecimiento del paciente, mientras que los cambios dentoalveolares fueron similares en adolescentes tratados durante el pico de crecimiento o en la adolescencia tardía[13]. Esto se diferencia del aparato funcional fijo de Herbst, el cual se ha observado que sí es capaz de producir un ligero avance mandibular en pacientes donde ya se ha finalizado la etapa de máximo crecimiento o pico de crecimiento puberal[13,53]. Bock et al confirman esta hipótesis en su estudio realizado a 26 pacientes adultos con edades comprendidas entre los 15 y 44 años tratados con Herbst y aparatología fija multi-bracket, donde gracias a sus efectos dentoalveolares se logró la corrección de las clase II división 1 con resultados estables, a pesar de que los efectos a nivel esquelético fueron mucho menores que en pacientes en crecimiento[53].

Por otro lado, Aynur Aras et al afirman que la literatura revisada propone al aparato de Herbst como el dispositivo funcional más efectivo a corto plazo; confirman la efectividad del Forsus™ a corto plazo pero determinan que se requieren más estudios para evaluar sus efectos a largo plazo, es decir, se necesita más evidencia científica para determinar si el avance mandibular es producido por el dispositivo en sí o se debe al crecimiento que experimenta el paciente de forma natural[13,37]. Bagliazzi et al confirman la estabilidad a largo plazo de los resultados obtenidos tras el tratamiento funcional con Bionator, manteniéndose incluso después de haber finalizado el crecimiento[30]. A su vez Mills y McCulloch et al aseguran el mantenimiento de los resultados obtenidos tras terapia ortodóncica con Twin Block, hasta 3 años después de haber finalizado el tratamiento[36]. Por el contrario, Xin Yang et al reportan en su revisión sistemática la necesidad de una mayor evidencia científica para confirmar la estabilidad de los resultados del Herbst a largo plazo[37]. En 2014, Pancherz et al evalúan los efectos del Herbst 32 años después de haber acabado el tratamiento, y confirman la existencia de resultados estables a largo plazo, siendo el periodo más susceptible a cambios los 6 años posteriores al tratamiento[54].

Con respecto a los cambios producidos en la articulación temporomandibular (ATM) existen ciertas diferencias. Aynur Aras et al evalúan los cambios producidos en la ATM tras el tratamiento de maloclusión de clase II con el aparato de rigidez media Forsus™ Fatigue Resistant con la ayuda de resonancias magnéticas y concluyen que el empleo de este dispositivo no genera una relación patológica entre las diferentes estructuras de la cavidad glenoidea, por lo que su uso no es un factor de riesgo de la aparición de disfunción temporomandibular[13]. A diferencia de Chaudry et al, quienes aseguran que tras el uso de aparatos funcionales fijos como el Forsus™ se genera un estrés en el cóndilo mandibular de hasta tres veces mayor que el existente antes del tratamiento[42]. Por otro lado, Keun-Young Lee et al o Doshi et al destacan que los cambios producidos en la ATM dependen de la duración del tratamiento, de las fuerzas empleadas durante el mismo, y concluyen con sus estudios que tras la utilización adecuada del aparato funcional Twin-block, se producen cambios favorables y adaptativos en la ATM (Fig.28), dando lugar a un crecimiento del cóndilo hacia atrás y hacia arriba, es decir, en dirección postero-superior[22,48]. De acuerdo con LeCornu et al, se determina que tras el uso del Herbst el cóndilo mandibular se desplaza hacia delante, dando lugar a una respuesta adaptativa en la que la cavidad glenoidea se desplaza anteriormente[43].

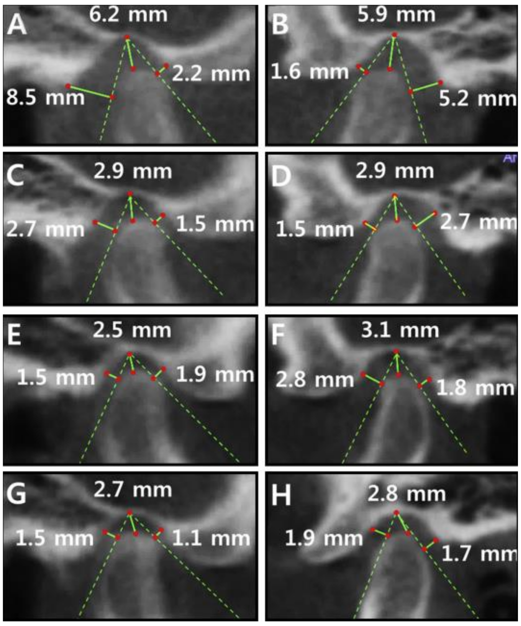

Fig.28. Respuesta adaptativa funcional del cóndilo con respecto a la cavidad glenoidea tras tratamiento con Twin Block. A, C, E, G: evolución de ATM derecha en distintas fases de tratamiento; B, D, F, H: evolución de ATM izquierda en distintas fases de tratamiento. (Leet et al, 2016)[22].

Diversos investigadores muestran distintas opiniones acerca de la influencia de la aparatología funcional sobre la altura del tercio facial inferior. Almeida et al, reportan en su estudio realizado a 22 pacientes tratados con Bionator durante un periodo de 16 meses, que el empleo del mismo ocasiona un aumento vertical de la altura facial posterior pero el patrón de crecimiento craneofacial no se ve alterado[23]. Sin embargo, en la revisión sistemática realizada por Flores-Mir y Major se reporta la existencia de estudios que destacan la aparición de cambios verticales faciales tras el tratamiento con Bionator o Frankel; y Bayram et al en 2017 demuestran el aumento de la altura facial anterior tras el tratamiento con el Forsus™ Fatigue Resistant[41,46]. En el meta-análisis realizado por Xin Yang et al en 2016, se destaca la inalterabilidad del patrón de crecimiento facial tras el uso del aparato de Herbst, sin producir cambios verticales[37].

La tendencia de investigación de los últimos años consiste en intentar mejorar el principal inconveniente de la aparatología funcional removible, es decir, la necesidad de colaboración de los pacientes con el tratamiento según lo propuesto por Pacha et al y Flemming et al en sus respectivos estudios de 2016 y 2020[55,56]. Por ello, en los últimos años han surgido varios intentos de desarrollar un dispositivo capaz de medir el tiempo real que el aparato removible ha permanecido puesto en boca[57,58].

Brierley et al en 2017 y Charavet et al en 2019, reportan que el último dispositivo diseñado con este objetivo es el microsensor Theramon® (Fig.29), dispositivo electrónico de última tecnología que se incorpora en el acrílico de los aparatos removibles y consta de unos microsensores que registran valores de temperatura cada 15 minutos, de modo que cifras comprendidas entre 33,5ºC y 39ºC se consideran como tiempo que el aparato funcional removible ha permanecido puesto en boca[57,58].

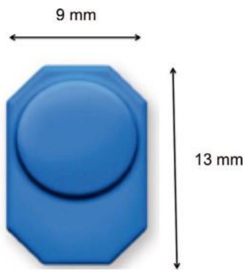

Fig.29. Diseño y tamaño del microsensor Theramon®[58]*.*

Los autores revelan que el dispositivo consta de un lector de estos microsensores (Fig.30) y un programa informático que el ortodoncista debe tener instalado en su consulta de forma que cada vez que el paciente acuda a revisión, el ortodoncista colocará en el lector el aparato funcional con el microsensor incorporado dentro del mismo y aparecerá en pantalla el número de horas que el aparato ha estado puesto en boca al día, mostrando una gráfica que permite al ortodoncista conocer el grado de colaboración del paciente con el tratamiento y valorar si la opción removible es la mejor para ese paciente (Fig.31)[57,58].

Fig.30. Lector del microsensor Theramon®[58]*.*

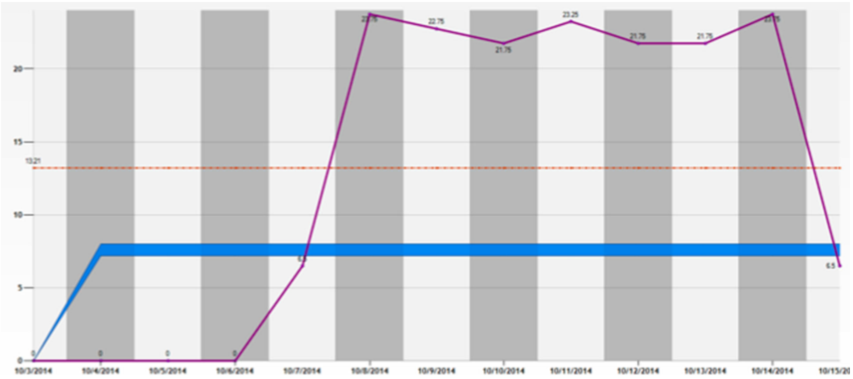

Fig.31. Ejemplo de la visualización en pantalla de la gráfica que muestra el número de horas al día que el paciente ha llevado el aparato funcional removible posicionado en boca [57]*.*

Esto fue aplicado a la aparatología funcional removible por Charavet et al en su estudio de 2019, donde evaluaron la función de los microsensores Theramon® incorporados en el acrílico de aparatos funcionales (Fig.32)[58]. Se realizó un seguimiento de 69 pacientes durante 9 meses cuyo tratamiento consistió en el uso de aparatología funcional removible durante las 24 horas del día y se observó una media de uso de los aparatos de 15,8 horas al día[58]. A diferencia de Brierley et al quienes reportaron una media de 13,21 horas al día[57].

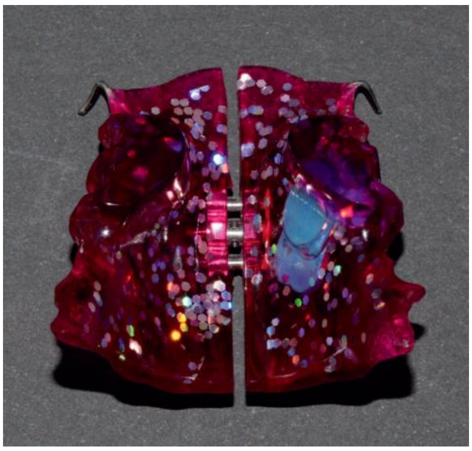

Fig.32. Aparato funcional con microsensor Theramon® incorporado en el acrílico[58]*.*

Charavet et al (2019) coinciden con Brierley et al (2017) en que estos microsensores permiten al ortodoncista tener un control del grado de colaboración, así como individualizar y seleccionar el mejor tratamiento para cada paciente, mejorando y facilitando de este modo la práctica clínica diaria de los profesionales[57,58].

CONCLUSIONES.

Tras el análisis y comparación de los artículos seleccionados y en respuesta a los objetivos de la presente revisión bibliográfica, se concluye que:

1. Existen múltiples alternativas de tratamiento con diferentes tipos de aparatología funcional capaces de lograr la corrección o mejora de las maloclusiones de clase II. Entre ellos destacan los Activadores, Bimler, Fränkel II, Bionator y Twin Block como opciones terapéuticas de tipo removible; y *Forsus™ Fatigue Resistant* y Herbst como opciones fijas.
2. La elección del aparato funcional se realizará teniendo en cuenta factores como la etiología de la maloclusión, la edad del paciente, el estado de crecimiento en el que se encuentra, el subtipo de maloclusión, la presencia de malposiciones dentarias y grado de colaboración del paciente con el tratamiento.
3. Los efectos que producen los aparatos funcionales sobre el crecimiento de la mandíbula son: un cambio en la dirección del crecimiento condiliar en sentido postero-superior, cambios en la magnitud del ángulo goníaco como la remodelación en el borde posterior e inferior de la mandíbula, un crecimiento y avance de la misma, y la aparición de un nuevo patrón neuromuscular. Sus efectos a nivel dentoalveolar varían en función del tipo de aparato y destacan la retroinclinación de los incisivos superiores, proinclinación de los incisivos inferiores, o una erupción mesial de sectores posterio-inferiores. Existe controversia con respecto a los efectos de la aparatología funcional en la restricción del crecimiento del maxilar superior.
4. Los principios generales de la aparatología funcional para maloclusiones de clase II se basan en el conocimiento del funcionamiento del aparato estomatognático,

del crecimiento y desarrollo mandibular, y del manejo de los diferentes elementos accesorios de cada aparato. El manejo clínico es muy variable y por tanto es objeto de debate entre los ortodoncistas. Se debe individualizar el tratamiento a cada paciente en función de las necesidades que presente. Es importante aprovechar los picos de crecimiento, teniendo en cuenta el dimorfismo sexual, ya que este determinará el momento ideal para iniciar el tratamiento.

5. La incorporación del microsensor Theramon® en el acrílico de los aparatos funcionales removibles de clase II, mejora la práctica clínica diaria de los ortodoncistas permitiendo al profesional evaluar el grado de colaboración de los pacientes con el tratamiento.

RESPONSABILIDAD.

La presente revisión bibliográfica resalta la importancia de la constante actualización por parte de los ortodoncistas para ofrecer a los pacientes calidad en sus tratamientos. Un buen manejo de los tratamientos con aparatología funcional en maloclusiones de clase II logra un impacto muy positivo en la salud, autoestima y, por tanto, calidad de vida de los pacientes; y en ocasiones gracias a estos tratamientos se evitan otros más invasivos en edades posteriores como son las extracciones por tratamiento ortodóncico o cirugías ortognáticas. Además, el presente trabajo aporta información relevante y reciente en la temática, cuyo conocimiento permite a los ortodoncistas mejorar la práctica clínica diaria y tomar decisiones de tratamiento más acertadas y adecuadas a cada paciente, las cuales serán siempre responsabilidad del profesional sanitario.

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ANEXOS.

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REVISTA ESPAÑOLA DE ORTODONCIA

Artículo original

Actualización acerca del crecimiento del cóndilo mandibular

José Chaqués Asensi

J. Chaqués

RESUMEN

La función que tiene el cartílago condilar en el proceso general de crecimiento mandibular ha sido investigada y discutida durante décadas. Los estudios en animales nos han facilitado diversos niveles de evidencia acerca de los cambios histológicos que se suceden en el cartílago condilar cuando se modifica experimentalmente el medio mecánico. Estos datos apoyan la noción actual de que el cartílago condilar puede sufrir cambios adaptativos en su actividad de crecimiento si se induce la protrusión mandibular de forma experimental. Por otro lado, el extendido uso de aparatos funcionales o dispositivos similares que empujan la mandíbula hacia delante ha planteado la cuestión de la potencial contribución de la alteración del crecimiento condilar a los cambios que se proponen con este tipo de terapia ortopédica. El propósito de este artículo se puede resumir de la siguiente manera: 1) proporcionar un breve resumen del papel atribuido al cartílago condilar durante el crecimiento mandibular, desde las teorías clásicas hasta el pensamiento actual; 2) describir las características distintivas del cartílago condilar; 3) debatir la información aportada por la experimentación en modelos animales, en particular la rata y el mono; 4) proponer un modelo del mecanismo de control implicado en la alteración del crecimiento del cartílago condilar mediante estimulación mecánica, y 5) debatir las implicaciones clínicas referentes a la utilización de aparatos que empujan la mandíbula hacia delante.

Palabras clave: *Crecimiento mandibular. Cartílago condilar. Hiperpropulsión mandibular. Crecimiento adaptativo. Control del crecimiento. Aparatos funcionales.*

Growth of the mandibular condyle: an update

J. Chaqués Asensi

ABSTRACT

The role played by the condylar cartilage in the overall process of mandibular growth has been the subject of investigation and debate for several decades. Animal studies have provided various levels of evidence of the histological changes that take place in the condylar cartilage under experimental modification of the mechanical environment. These data support the current thinking that the condylar cartilage may undergo adaptive changes of its growth activity under experimentally induced mandibular protrusion. On the other hand, the widespread use of functional appliances, or similar appliances that position the mandible forward, has raised the question of the potential contribution of condylar growth modification to the changes aimed with this kind of orthopedic therapy. The purpose of this review can be summarized as follows: (i) To provide a brief summary of the role attributed to the condylar cartilage in mandibular growth, from the classic theories to current thinking; (ii) to describe the distinctive features of condylar cartilage; (iii) to discuss the information provided by experimentation in animal models, namely the rat and the monkey; (iv) to propose a model of the control mechanism involved in growth modification of the condylar cartilage under mechanical stimulation; and (v) to discuss the clinical implications relative to the clinical use of appliances that induce a forward positioning of the mandible. (Rev Esp Ortod. 2015;45:217-26).

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Key words: *Mandibular growth. Condylar cartilage. Mandibular hyper-propulsion. Adaptive growth. Growth control. Functional appliances.*

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Postnatal changes in the growth dynamics of the human face revealed from bone modelling patterns

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Abstract

Human skull morphology results from complex processes that involve the coordinated growth and interaction of its skeletal components to keep a functional and structural balance. Previous histological works have studied the growth of different craniofacial regions and their relationship to functional spaces in humans up to 14 years old. Nevertheless, how the growth dynamics of the facial skeleton and the mandible are related and how this relationship changes through the late ontogeny remain poorly understood. To approach these two questions, we have compared the bone modelling activities of the craniofacial skeleton from a sample of subadult and adult humans. In this study, we have established for the first time the bone modelling pattern of the face and the mandible from adult humans. Our analyses reveal a patchy distribution of the bone modelling fields (overemphasized by the presence of surface islands with no histological information) reflecting the complex growth dynamics associated to the individual morphology. Subadult and adult specimens show important differences in the bone modelling patterns of the anterior region of the facial skeleton and the posterior region of the mandible. These differences indicate developmental changes in the growth directions of the whole craniofacial complex, from a predominantly downward growth in subadults that turns to a forward growth observed in the adult craniofacial skeleton. We hypothesize that these ontogenetic changes would respond to the physiological and physical requirements to enlarge the oral and nasal cavities once maturation of the brain and the closure of the cranial sutures have taken place during craniofacial development.
Key words: bone formation and resorption bone histology; facial skeleton; *Homo sapiens*; mandible; modelling pattern; morphology; ontogeny.

Introduction

The skull is an anatomically complex system, which has been a focal point for studies in vertebrate biology for more than two centuries. It presents unique opportunities to examine the role of the multiple, intricate developmental processes involved in the craniofacial morphology and in the evolutionary origin of the hominid cranium (de Beer, 1937; Enlow, 1975; Atchley & Hall, 1991; Lieberman, 2011). Understanding the development of the skull can be achieved through the study of the growth dynamics of their skeletal elements considering the Moss functional matrices theory (Moss & Young, 1960; Moss & Rankow, 1968; Moss & Salentijn, 1969; Moss, 1997c,d) and the Enlow counterpart principle (Enlow et al. 1969; Enlow & Hans, 1996). According to this theoretical framework, the human craniofacial skeleton results from the interactions of their different components that are influenced by both internal (hormonal and genetic factors; e.g. Moss & Young, 1960; Enlow & Hans, 1996; Tomoyasu et al. 2009; Lieberman, 2011) and external stimuli (soft tissue growth, dental maturation, biomechanical factors; e.g. Moss, 1997a,b,c,d; Atchley & Hall, 1991; Enlow & Hans, 1996; Lieberman et al. 2002; Klingenberg et al. 2003; Lieberman, 2011; Gröning et al. 2013). The growth of the skeletal elements involves changes in their size and shape as well as their relative position within the craniofacial system in order to maintain the proper bone alignment, function and proportionate growth (e.g. O'Higgins et al. 1991; Enlow & Hans, 1996; McCollum, 2008; Lieberman, 2011). During the human development, the skeletal elements from the neurocranium, viscerocranium and mandible are intimately associated to the functional spaces (cranial, orbital, nasal and oral cavities) and the soft tissues in which they are embedded (e.g. brain, muscles, connective tissues) (Moss & Young, 1960; Enlow & Hans, 1996; see also Lieberman, 2011 and cites there in).

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Revisión bibliográfica

La mandíbula: su rotación durante el crecimiento. Una revisión bibliográfica (I).

S. Luckow S. Ochandiano Caicoya J. C. Rivero Lesmes

Palabras clave: Mandíbula. Crecimiento mandibular. Crecimiento rotacional. Rotación mandibular.

The mandible: it¿s roration during growth. A bibliographic review (I).

The aim of this study is to clarify and summarize the related concepts and nomenclature of mandibular rotation. In the first article wil be exposed the primary rotation, also called intramatrix rotation or morphogenetic rotation. It is the rotation between the mandibular corpus and the ascending ramus. It is anterior when the mandibular corpus rotates upward respect the mandibular line, and posterior when declines. This opposite rotations generate remodelings that cause different mandibular morphologies.

Keywords: Mandible. Mandibular growth. Rotational growth. Mandibular rotation.

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REVISIÓN BIBLIOGRÁFICA

La mandíbula: su rotación durante el crecimiento. Una revisión bibliográfica (I)

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RESUMEN: El objetivo de esta revisión bibliográfica es conjuntar las

La mandíbula: su rotación durante el crecimiento. Una revisión bibliográfica (II)[1]

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RESUMEN: El objetivo de esta revisión bibliográfica es conjuntar las diferentes definiciones y conceptos que rodean al término de *rotación mandibular*. La rotación primaria, también denominada rotación intramatricial o rotación morfogenética, es la rotación entre el cuerpo y la rama mandibular. Ésta es anterior cuando el cuerpo rota hacia arriba con respecto a la línea mandibular y posterior cuando desciende. Estas dos rotaciones opuestas generan una serie de remodelados que dan lugar a morfologías mandibulares diferentes. En la rotación secundaria, también descrita como rotación matricial o rotación posicional, toda la mandíbula rota teniendo como eje a los cóndilos. No genera ningún remodelado óseo y depende del desarrollo de otros huesos. Es anterior cuando la mandíbula rota hacia arriba y adelante y posterior cuando rota hacia abajo y atrás con respecto a la base craneal anterior. La rotación total de la mandíbula es la suma de las rotaciones primaria y secundaria que sufre la mandíbula durante un período determinado del crecimiento. Conocer cómo y por qué rota una mandíbula es de utilidad en el diagnóstico y tratamiento de una maloclusión con discrepancia entre las bases óseas, para saber cuál es el papel que realmente juega en esa maloclusión.

PALABRAS CLAVE: Mandíbula. Crecimiento mandibular. Crecimiento rotacional. Rotación mandibular.

THE MANDIBLE: IT'S ROTATION DURING GROWTH. A BIBLIOGRAPHIC REVIEW (II)

ABSTRACT: The aim of this study is to clarify and summarize the related concepts and nomenclature of *mandibular rotation*. The primary rotation, also called intramatrix rotation or morphogenetic rotation, is the rotation between the mandibular corpus and the ascending ramus. It is anterior when the mandibular corpus rotates upward respect the mandibular line, and posterior when declines. This opposite rotations generate remodelings that cause different mandibular morphologies. In secondary rotation, also called matrix rotation or positional rotation, the whole mandible rotates with the axis in the condyles. There is no remodeling as a consecuence of secondary rotation, and is due to growth of other bones of the skull. It is anterior when the mandible rotates upward and forward, and posterior when the rotation is dounward and backward respect the anterior cranial base. Total mandibular rotation is the addition of primary and secondary rotation of the mandible during a growth period. To know why and how a mandible rotates is usefull in diagnosis and treatment of malocclusion with bone discrepancy, as to find out the role of rotation in a individual malocclusion.

KEY WORDS: Mandible. Mandibular growth. Rotational growth. Mandibular rotation.

ROTACIÓN SECUNDARIA

Se entiende por rotación secundaria a la rotación en masa de toda la mandíbula con respecto a la base craneal anterior. Björk y Skieller[1] la definen como la rotación de la matriz, y dicen que es la rotación de la matriz de tejido blando de la mandíbula con relación a la base craneal anterior. Definen a la matriz de tejido blando mandibular como la línea tangencial del borde mandibular inferior. La rotación de la matriz se puede describir como un movimiento pendular con los cóndilos como centro de rotación (Fig. 1). Los cambios de inclinación del borde mandibular inferior durante el crecimiento expresan la rotación de la matriz de tejido blando. Esto se mediría en la variación del ángulo ML-SNL, siendo la rotación anterior una disminución de este ángulo (Fig. 2) y la posterior un aumento del mismo (Fig. 3).

Al igual que en la rotación primaria, podemos volver a analizar qué sucede al considerar la variación del ángulo RL-SNL (Figs. 4 y 5) como el valor de la rotación secundaria[2]. Se ha dicho que el remo-

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REVIEW

Three-dimensional analysis of mandibular growth and tooth eruption

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Abstract

Normal and abnormal jaw growth and tooth eruption are topics of great importance for several dental and medical disciplines. Thus far, clinical studies on these topics have used two-dimensional (2D) radiographic techniques. The purpose of the present study was to analyse normal mandibular growth and tooth eruption in three dimensions based on computer tomography (CT) scans, extending the principles of mandibular growth analysis proposed by Björk in 1969 from two to three dimensions. As longitudinal CT data from normal children are not available (for ethical reasons), CT data from children with Apert syndrome were employed, because it has been shown that the mandible in Apert syndrome is unaffected by the malformation, and these children often have several craniofacial CT scans performed during childhood for planning of cranial and midface surgery and for follow-up after surgery. A total of 49 datasets from ten children with Apert syndrome were available for study. The number of datasets from each individual ranged from three to seven. The first CT scan in each of the ten series was carried out before 1 year of age, and the ages for the 49 scans ranged from 1 week to 14.5 years. The mandible and the teeth were segmented and iso-surfaces generated. Landmarks were placed on the surface of the mandible, along the mandibular canals, the inner contour of the cortical plate at the lower border of the symphysis menti, and on the teeth. Superimposition of the mandibles in the longitudinal series was performed using the symphysis menti and the mandibular canals as suggested by Björk. The study supported the findings of stability of the symphysis menti and the mandibular canals as seen in profile view previously reported by Björk & Skieller in 1983. However, the mandibular canals were, actually, relocated laterally during growth. Furthermore, the position of tooth buds remained relatively stable inside the jaw until root formation started. Eruption paths of canines and premolars were vertical, whereas molars erupted in a lingual direction. The 3D method would seem to offer new insight into jaw growth and tooth eruption, but further studies are needed.

Key words CT; development; facial growth; jaw; three dimensions.

Introduction

Normal and abnormal facial growth and tooth eruption are topics of great importance for several dental disciplines, such as pedodontics, orthodontics, and oral and maxillofacial surgery. All clinical studies have, thus far, been carried out using two-dimensional (2D) roentgencephalometric techniques (e.g. Björk, 1968; Björk & Kuroda, 1968; Björk & Skieller, 1972, 1983).

The techniques of roentgencephalometry were originally developed 70 years ago by orthodontic researchers (Hofrath, 1931; Broadbent, 1931), searching for a method that would make possible the longitudinal study of growth of the jaws in children through standardized,

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Treatment of Class II malocclusions by jumping the bite with the Herbst appliance

A cephalometric investigation

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The possibility of affecting condylar growth in the treatment of Class II malocclusion is still a highly debated subject. Experimental studies on growing monkeys have shown that a functional forward displacement of the mandible can stimulate growth in the condylar cartilage.[1-5] Clinical studies in man, on the other hand, give some contradicting results. Some investigators claim that during activator treatment of Class II malocclusions in children mandibular growth could be stimulated,[6-10] while others are of the opinion that functional therapy has no effect on condylar growth.[11-15] However, when the above-mentioned studies in the animals were compared with those in man, some important differences were noted. In the animal experiments the appliances used were fixed intermaxillary splints with inclined planes forcing the mandible anteriorly during closure. The activator, on the other hand, is a removable appliance used mainly at night and requiring perfect cooperation from the patient.

In 1905 Herbst[16] introduced a fixed appliance for Class II treatment which did not require the patient's cooperation. The appliance kept the mandible in a continuous protruded position both during jaw closure and when the teeth were not in occlusion; for example, all function (speech, chewing, swallowing) was performed with the mandible in an anterior jumped position. Herbst claimed that condylar growth could be stimulated by his method of treatment, but no real proof could be presented.

The aim of the present investigation was to analyze the effect of continuous bite jumping with the Herbst appliance on the occlusion and craniofacial growth during treatment of Class II malocclusions in growing children. The investigation attempted especially to determine whether sagittal mandibular growth could be stimulated by treatment. The effect of continuous bite jumping on the activity of the masticatory muscles will be considered in a later report.

Material

For this specific experimental set-up, twenty boys with Class II, Division 1 malocclusion were selected from the patients registered for treatment at the Department of Orth-

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RESEARCH ARTICLE

Long-term effects of functional appliances in treated versus untreated patients with Class II malocclusion: A systematic review and meta-analysis

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Abstract

Objective

To assess the cephalometric skeletal and soft-tissue of functional appliances in treated versus untreated Class II subjects in the long-term (primarily at the end of growth, secondarily at least 3 years after retention).

Search methods

Unrestricted electronic search of 24 databases and additional manual searches up to March 2018.

Selection criteria

Randomised and non-randomised controlled trials reporting on cephalometric skeletal and soft-tissue measurements of Class II patients (aged 16 years or under) treated with functional appliances, worn alone or in combination with multi-bracket therapy, compared to untreated Class II subjects.

Data collection and analysis

Mean differences (MDs) and 95% confidence intervals (95% CIs) were calculated with the random-effects model. Data were analysed at 2 primary time points (above 18 years of age, at the end of growth according to the Cervical Vertebral Maturation method) and a secondary time point (at least 3 years after retention). The risk of bias and quality of evidence were assessed according to the ROBINS tool and GRADE system, respectively.

Stomatologija, Baltic Dental and Maxillofacial Journal, 7:16-20, 2005

Mandibular Pubertal Growth Spurt Prediction. Part One: Method Based on the Hand-Wrist Radiographs

Antanas Šidlauskas, Laura Žilinskaitė, Vilma Švalkauskienė

SUMMARY

Many orthodontic treatment modalities will yield a better result in less time if properly correlated with the unique facial growth patterns of the patients. The pubertal growth spurt depends on gender and varies in relationship to the chronologic age. General skeletal maturity usually is used as an indicator to predict timing of mandibular growth velocity peak. Hand–wrist radiographic evaluation is one of the diagnostic tools currently available to determine whether the pubertal growth has started, is occurring or has finished. The overview of topic related literature and skeletal maturity assessment (SMA) system developed by L.Fishman are presented. The SMA system is based on eleven discrete adolescence skeletal maturational indicators of hand-wrist bones, covering the entire period of adolescent development. Maturational stage and level demonstrated close correlation with maxillary and mandibular growth velocity, amount of incremental growth and timing. Clinical indications for the use of hand-wrist radiographs to assess skeletal maturity are provided.

Key words: orthodontic treatment, hand–wrist radiographs, pubertal growth spurt

Understanding the development patterns of every growing patient is one of the prerequisites for successful orthodontic treatment. Many treatment modalities will yield a better result in less time if properly correlated with the facial growth patterns that are associated with the patient (1). Growth related appliances such as functional appliances, extraoral traction (headgear, facial mask), Herbst appliances must be used during periods of significant growth. Maxillofacial surgery contrarily, can be done only after the pubertal growth is over, because substantial growth afterwards may cause relapse. Early orthodontic treatment is often required during the mixed dentition if the skeletal maturation indicates growth velocity periods would be missed by waiting for more permanent teeth to erupt. On the other hand early orthodontic treatment is contraindicated if very little facial growth present.

Considerable variations exist in the timing of the development of different parts of craniofacial complex. Neurocranium growth completes approximately 80% of total growth by 6 to 8 years of age. The midface and the mandible have considerable amount of their total growth remaining between ages of 10 and 20 years. This makes possible to have a significant treatment impact on their final size during that time period. Orthodontists particularly are interested in the growth of mandible, because of its determinant role in the development of the anteroposterior relationship between the jaws. Mandibular growth is a target for dentofacial orthopedic therapy. Remarkable growth occurs of mandible during puberty. The pubertal growth spurts are dependent on gender and vary in their relationship to the chronologic age (2). These variations determine the speed and the duration of the growth processes. In girls, pubertal growth spurt usually starts between the ages 10 and 12 years, in boys between 12 and 14 years. Many studies have shown an association between peak velocity of facial growth and peak velocity of statural growth during puberty (3, 4, 5). It has also been demonstrated that the pattern of mandibular growth coincides with body height growth in adolescents (6). For the didactic purposes we can say that growth in height velocity curve approximately represents growth pattern of mandible (fig. 1). In fact mandibular growth, however, shows wide ranges of variability in amount, velocity and timing (7). Among these variables growth timing, which is the most critical for orthodontic treatment planning, can vary regarding the mean chronological age from 2 to 3 years on each side! It is obvious that chronological age is not sufficient for assessing the development stage of the mandible and the biological age or skeletal maturity has to be determined. General skeletal maturity usually is used as an indicator to predict timing of mandibular growth velocity peak. There are many methods attempting to measure general skeletal maturity. For this purpose body height (8), hand–wrist growth (9), sexual maturity (10) or cervical vertebrae bone age (11, 12, 13) are used. The first our article will attempt overview the relationship between the hand–wrist maturation stage, maturation level and growth changes in mandible. The second article will analyze correlations between cervical vertebrae maturation and prediction of mandible growth spurt.

Several human growth studies have shown that the timing of the pubertal growth velocity peak in statural height, as well as growth of mandible, is closely related to specific ossification events observed in the hand–wrist area (14, 15). Hand–wrist radiographic evaluation is one of the diagnostic tools currently used to determine whether the pubertal growth has started, is occurring or has finished (16). L.Fishman (17) developed a system of Skeletal Maturation Assessment (SMA). The system is based on the observation of ossification events localized in the area of the finger phalanges, carpal bone and radius. These processes were compared with mandibular pubertal growth spurt and close correlation between sequence of hand-wrist ossification and mandibular growth status was found. To understand the SMA it is necessary to remember the development of the hand and wrist. The initial skeletal component of a finger phalanx in embryo is cartilage. Bone replaces cartilage by a process termed endochondral bone ossification. Every phalanx has two centers of ossification. The primary ossification center appears in the central part of the phalanx (*dia-*

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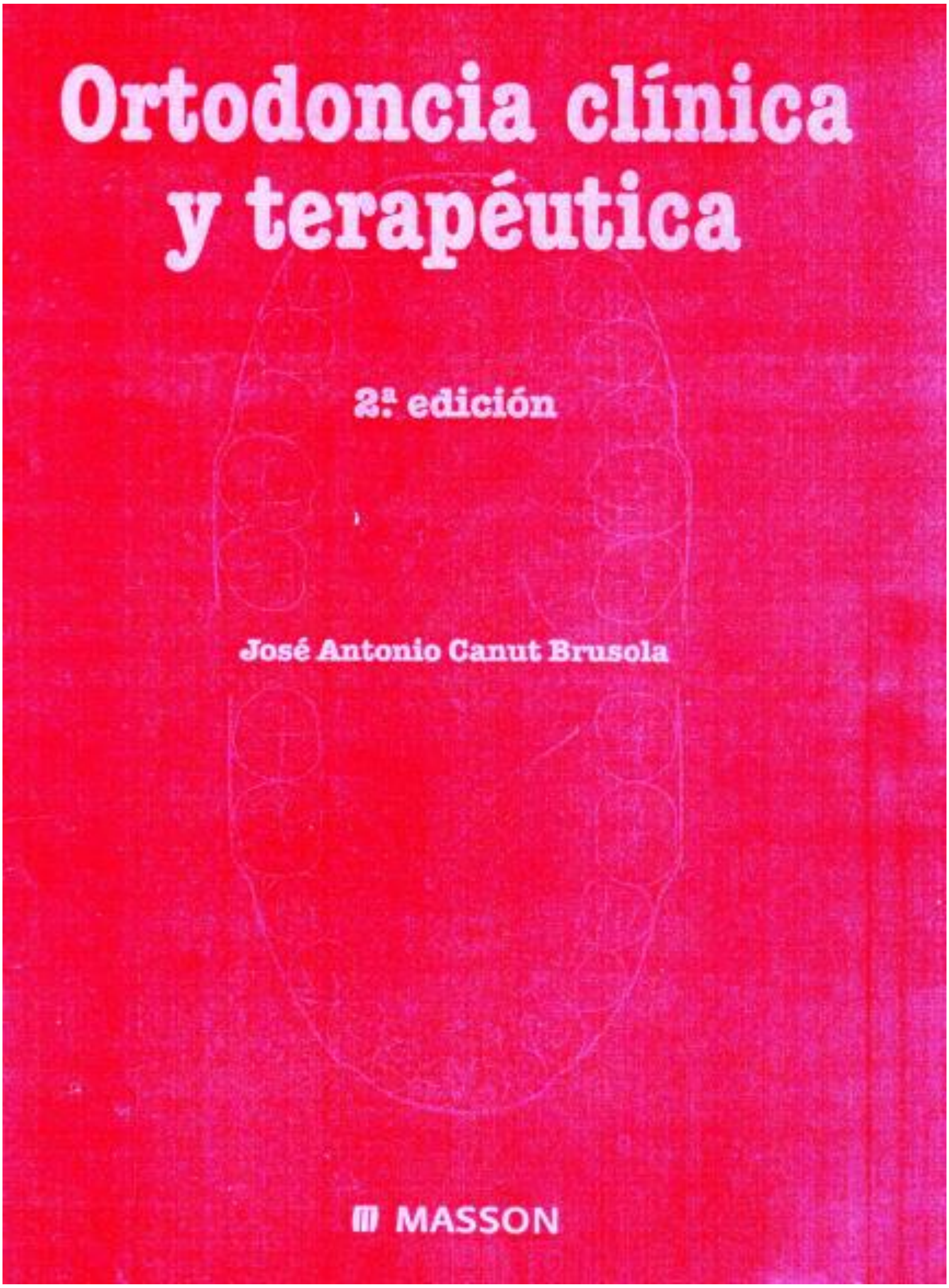
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Phenotypic Diversity in Caucasian Adults with Moderate to Severe Class II Malocclusion

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Abstract

INTRODUCTION—Class II malocclusion affects about 15 % of the US population and is characterized by a convex profile and occlusion disharmonies. The specific etiological mechanisms resulting in the range of Class II dento-skeletal combinations observed is not yet understood. Most studies describing the class II phenotypic diversity have utilized moderate sample sizes or have focused on younger individuals that later in life may outgrow their class II discrepancies; such a focus may also preclude the visualization of adult class II features. The majority have utilized simple correlation methods resulting in phenotypes that may not be generalizable to different samples and thus may not be suitable for studies of malocclusion etiology. The purpose of this study is to address these knowledge gaps by capturing the maximum phenotypic variation present in a large Caucasian sample of class II individuals selected with strict eligibility criteria and rigorously standardized multivariate reduction analyses.

METHODS—Sixty-three lateral cephalometric variables were measured from pre-treatment records of 309 Class II Caucasian adults (82 males, 227 females; ages 16–60 years). Principal component analysis (PCA) and cluster analysis were used to generate comprehensive phenotypes in an effort to identify the most homogeneous groups of individuals reducing heterogeneity and improving the power of future malocclusion etiology studies.

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Alveolar and dental arch morphology in Angle Class II division 2 malocclusion: a comparative study

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Abstract

Objective: The aim of this study was to analyze the dental and alveolar intercanine, interpremolar and intermolar widths in patients with Class II/2 malocclusion and to compare the data with a patient group with normal occlusion and also with a patient group with Class II/1 malocclusion. *Materials and Methods*: The study was conducted on 140 untreated patients with permanent dentition, aged 16 to 25 years, which were divided into three groups, according to Angle's classification of occlusion. The measurements of the dento-alveolar intercanine, interpremolar and intermolar widths were made on virtual study models, scanned using an optical 3D scanner. The unpaired (Student's) *t*-test was used to determine whether there were any significant differences between the Class II/2 and Class I groups and between Class II/2 and Class II/1 groups, respectively ($p<0.05$). *Results*: Significant differences were found between Class II/2 and Class II/1 groups in the maxillary and mandibular intercanine widths. Comparing the Class II/2 and Class I groups, significant differences were found in the mandibular intercanine width, in the maxillary and mandibular interpremolar widths and also in the maxillary and mandibular intercanine and interpremolar alveolar widths. *Conclusions*: The maxillary and mandibular interpremolar widths and the intercanine and interpremolar alveolar widths were larger, while the mandibular intercanine width was shorter in the Class I group than in the Class II division 2 group. The mandibular intercanine width was longer and the maxillary intercanine width was shorter in the Class II division 1 group compared to the Class II division 2 group.

Keywords: Class II division 2 malocclusion, dental arch width, alveolar arch width, optical 3D scanner, study model.

Introduction

Angle Class II malocclusion is a common type of malocclusion [1–4], but the actual prevalence of this type of malocclusion proves to be difficult to establish because of the inconsistencies found in the research methodology and the differences in racial and ethnic characteristics among the samples. Comparing Angle Class II division 1 (Class II/1) and Class II division 2 (Class II/2) malocclusions, the Class II/2 type is less common [4–6].

The morphology of the alveolar and dental arches has important implications in orthodontics, influencing the available space, the stability of the dentition and the overall esthetics [7]. The study of arch width has been a subject of significant importance for orthodontic diagnosis and treatment planning [7, 8], because the growth in the transverse plane is the first dimension in which growth is "completed" [9].

Significant differences are found in the literature regarding the dento-alveolar transverse dimensions between patients with normal (Class I) occlusion and Class II malocclusion [10, 11], but also between Class II/1 and Class II/2 malocclusions [10, 12, 13].

The aim of this study was to analyze the transverse dimensions of the maxillary and mandibular dental and alveolar arch in the canine, premolar and molar region in patients with Class II/2 malocclusion and to compare the collected data with a patient group with normal occlusion and also with a patient group with Class II/1 malocclusion.

Materials and Methods

The present study was conducted in the Department of Pedodontics and Orthodontics, Faculty of Dental Medicine, "Victor Babeş" University of Medicine and Pharmacy, Timişoara, Romania, between April and July 2012, on a group of 140 untreated patients ranging in age from 16 to 25 years.

All subjects had permanent dentition and none of them had undergone orthodontic treatment before. The patients were divided into three groups according to Angle's classification of occlusion (Table 1). The control group consisted of patients with normal (Class I) occlusion.

Maxillary and mandibular superhard plaster study

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Changes in Soft Tissue Profile Using Functional Appliances in the Treatment of Skeletal Class II Malocclusion

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SUMMARY
Introduction The effects of orthodontic treatment are considered to be successful if the facial harmony is achieved, while the structures of soft tissue profile are in harmony with skeletal structures of neurocranium and viscerocranium. In patients with skeletal distal bite caused by mandibular retrognathism, facial esthetics is disturbed often, in terms of pronounced convexity of the profile and change in the position and relationship of the lips.
Objective The aim of this study was to determine the extent of soft tissue profile changes in patients with skeletal Class II malocclusion treated with three different orthodontic appliances: Fränkel functional regulator type I (FR-I), Balters' Bionator type I and Hotz appliance.
Methods The study included 60 patients diagnosed with skeletal Class II malocclusion caused by mandibular retrognathism, in the period of early mixed dentition. Each subgroup of 20 patients was treated with a variety of orthodontic appliances. On the lateral cephalogram, before and after treatment, the following parameters were analyzed: T angle, H angle, the height of the upper lip, the position of the upper and lower lip in relation to the esthetic line. Within the statistical analysis the mean, maximum, minimum, standard deviation, coefficient of variation, two-factor analysis of variance with repeated measures and the factor analysis of variance were calculated using ANOVA, Bonferroni test and Student's t-test.
Results A significant decrease of angles T and H was noticed in the application of FR-I, from 21.60° to 17.15°, and from 16.45° to 13.40° ($p<0.001$). FR-I decreased the height of the upper lip from 26.15 mm to 25.85 mm, while Hotz appliance and Balters' Bionator type I increased the height of the upper lip, thereby deteriorating esthetics of the patient.
Conclusion All used orthodontic appliances lead to changes in soft tissue profile in terms of improving facial esthetics, with the most distinctive changes in the application of Fränkel's functional regulator type I, which is the most successful appliance for achieving the overall facial harmony of the patient.
Keywords: Fränkel functional regulator; malocclusion, Angle Class II; orthodontic appliances, functional; soft tissue profile

INTRODUCTION

Skeletal Class II malocclusion is an orthodontic malocclusion that is very commonly found in the general population and requires a comprehensive treatment, considering that in addition to the disturbed occlusal morphology and functional variations, changes in facial esthetics and soft tissues are often present, which are one of the primary reasons why patients go to the orthodontist for help. Functional appliances can successfully affect not only skeletal and dentoalveolar structures, but also changed soft tissues of the face, resulting in harmony of the soft tissues with craniofacial structures, and providing significantly more acceptable facial appearance of the patient, primarily profile [1].

OBJECTIVE

The aim of this study was to determine how can different types of orthodontic appliances – Fränkel functional regulator type I (FR-I), Balters' Bionator type I and Hotz appliance – cause changes in soft tissue profile in the treatment of distal skeletal bite during the period of intensive growth.

METHODS

The study included 60 patients with skeletal Class II malocclusion (the angle ANB>4°). The entire sample was divided into 3 subgroups, with 20 patients in each: the first subgroup (Ia) was treated with the FR-I, the second subgroups (Ib) was treated with Balters' Bionator type I, and the third subgroup (Ic) was treated with Hotz appliance with a frontal inclined plane. All patients were in the age before the pubertal growth spurt, and because of that they were not divided by gender. There were 28 boys and 32 girls, 10 boys and 10 girls in subgroup Ia and Ib each, and 12 girls and 8 boys in subgroup Ic. Average chronologic age in the whole group was 9 years and 9 months, in subgroup Ia 8 years and 9 months, in Ib 10 years and 7 months, in Ic 10 years and 2 months. Clinical and functional analysis, analysis of study models, orthopantomogram (Siemens orthopantomograph 10, exposure 14 s) and lateral cephalogram (Philips,

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ORIGINAL ARTICLE

AJO-DO

Comparison of treatments with the Forsus fatigue resistant device in relation to skeletal maturity: A cephalometric and magnetic resonance imaging study

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Introduction: The aim of this study was to compare the dentoskeletal changes and alterations of mandibular condyle-disc-fossa relationships in subjects at the peak and the end of the pubertal growth period treated with the Forsus fatigue resistant device (3M Unitek, Monrovia, Calif). **Methods:** The sample consisted of 29 subjects with Class II Division 1 malocclusions who were classified according to their hand-wrist radiographs. Fifteen patients were at or just before the peak phase of pubertal growth (peak pubertal group). Fourteen patients were near the end of the pubertal growth period (late pubertal group). The study was conducted by using lateral cephalometric radiographs and magnetic resonance images obtained at the beginning and at the end of the application of the Forsus fatigue resistant device. The treatment period was 9 months. **Results:** The Wilcoxon signed rank test was used to evaluate differences within groups. The changes observed in both groups were compared by using the Mann-Whitney U test. There were statistically significant group differences in mandibular length and ramus length, with significant increases of these parameters in the peak pubertal group ($P < 0.05$). No significant differences were observed between the groups concerning dental parameters ($P > 0.05$), with the exception of mandibular molar vertical movements, which were significantly greater in the peak pubertal group ($P < 0.05$). Analysis of the magnetic resonance images showed no positional changes of the mandibular condyle in relation to the glenoid fossa in either group ($P > 0.05$). Although the articular disc was positioned more anteriorly in the peak pubertal group compared with its pretreatment position ($P < 0.05$), the position of the disc was still within the physiologic range. No significant intergroup difference was observed for disc-condyle relationship ($P > 0.05$). **Conclusions:** The Forsus fatigue resistant device did not appear to cause significant increases in mandibular dimensions in subjects in late puberty. According to the magnetic resonance image findings, Forsus treatment is not a risk factor for the development of temporomandibular dysfunction in subjects with no signs and clinical symptoms of dysfunction. (Am J Orthod Dentofacial Orthop 2011;140:616-25)

Class II malocclusions are a major part of orthodontic irregularities. The research suggests that mandibular retrognathia is the underlying cause, rather than maxillary prognathism.[1] In these patients, to stimulate mandibular growth by forward positioning of the mandible, removable or fixed functional orthopedic appliances are used.[2-4]

It has been reported that the effectiveness of functional therapy depends on both the treatment timing (skeletal maturity at the start of functional therapy) and the type of functional appliance.[5-7] According to several studies, mandibular growth can extend beyond puberty, and minimal residual growth can only be stimulated with fixed functional appliances.[8-12]

Ruf and Pancherz,[9,10] Konik et al,[11] and Kinzinger and Diedrich[12] stated that the treatment of late adolescents and young adults with rigid fixed functional appliances such as the Herbst or functional mandibular advancer resulted in correction of the Class II malocclusion with the skeletal and dental changes. However, the

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Review

Class II functional orthopaedic treatment: a systematic review of systematic reviews

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SUMMARY This Systematic Review (SR) aims to assess the quality of SRs and Meta-Analyses (MAs) on functional orthopaedic treatment of Class II malocclusion and to summarise and rate the reported effects. Electronic and manual searches were conducted until June 2014. SRs and MAs focusing on the effects of functional orthopaedic treatment of Class II malocclusion in growing patients were included. The methodological quality of the included papers was assessed using the AMSTAR (Assessment of Multiple Systematic Reviews). The design of the primary studies included in each SR was assessed with Level of Research Design scoring. The evidence of the main outcomes was summarised and rated according to a scale of statements. 14 SRs fulfilled the inclusion criteria. The appliances evaluated were as follows: Activator (2 studies), Twin Block (4 studies), headgear (3 studies), Herbst (2 studies), Jasper Jumper (1 study), Bionator (1 study) and Fränkel-2 (1 study). Four studies reviewed several functional appliances, as a group. The mean AMSTAR score was 6 (ranged 2–10). Six SRs included only controlled clinical trials (CCTs), three SRs included only randomised controlled trials (RCTs), four SRs included both CCTs and RCTs and one SR included also expert opinions. There was some evidence of reduction of the overjet, with different appliances except from headgear; there was some evidence of small maxillary growth restrain with Twin Block and headgear; there was some evidence of elongation of mandibular length, but the clinical relevance of this results is still questionable; there was insufficient evidence to determine an effect on soft tissues.

KEYWORDS: malocclusion angle class II/therapy, orthodontic appliances functional, review literature as topic, evidence-based dentistry, adolescent, growth and development

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Background

Class II malocclusion is one of the most frequently encountered orthodontic issue as it occurs in about one-third of the population (1). The efficacy of the functional orthopaedic treatments for such malocclusion is a widely debated topic, with controversial results in orthodontic literature (2).

Systematic Reviews (SRs) and Meta-analyses (MAs) are generally considered appropriate study design for offering a strong level of evidence (3), especially on controversial topics. In addition, SRs are one of the best ways to stay up to date with current medical literature (4) instead of reading an average of 17–20 articles per day (5). A well-conducted SR aims to collect and synthesise all the scientific evidence on a specific topic, according to strict predetermined inclusion and exclusion criteria (6). When possible, SRs might

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Mandibular changes produced by functional appliances in Class II malocclusion: A systematic review

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The aim of this systematic review of the literature was to assess the scientific evidence on the efficiency of functional appliances in enhancing mandibular growth in Class II subjects. A literature survey was performed by applying the Medline database (Entrez PubMed). The survey covered the period from January 1966 to January 2005 and used the medical subject headings (MeSH). The following study types that reported data on treatment effects were included: randomized clinical trials (RCTs), and prospective and retrospective longitudinal controlled clinical trials (CCTs) with untreated Class II controls. The search strategy resulted in 704 articles. After selection according to the inclusion/exclusion criteria, 22 articles qualified for the final analysis. Four RCTs and 18 CCTs were retrieved. The quality standards of these investigations ranged from low (3 studies) to medium/high (6 studies). Two-thirds of the samples in the 22 studies reported a clinically significant supplementary elongation in total mandibular length (a change greater than 2.0 mm in the treated group compared with the untreated group) as a result of overall active treatment with functional appliances. The amount of supplementary mandibular growth appears to be significantly larger if the functional treatment is performed at the pubertal peak in skeletal maturation. None of the 4 RCTs reported a clinically significant change in mandibular length induced by functional appliances; 3 of the 4 RCTs treated subjects at a prepubertal stage of skeletal maturity. The Herbst appliance showed the highest coefficient of efficiency (0.28 mm per month) followed by the Twin-block (0.23 mm per month). (Am J Orthod Dentofacial Orthop 2006;129:599.e1-599.e12)

Class II malocclusion is one of the most common orthodontic problems, and it occurs in about one third of the population.[1-3] The most consistent diagnostic finding in Class II malocclusion is mandibular skeletal retrusion. A therapy able to enhance mandibular growth is indicated in these patients.[4,5] A wide range of functional appliances aimed to stimulate mandibular growth by forward posturing of the mandible is available to correct this type of skeletal and occlusal disharmony.[5] Although many studies in animals have demonstrated that skeletal mandibular changes can be produced by posturing the mandible forward,[6-8] the effects on humans are more equivocal and controversial. Many treatment protocols, sample sizes, and research approaches have led to disparate outcomes in studies on human subjects.

A previous systematic review on the efficacy of functional appliances on mandibular growth by Chen et al[9] analyzed the relevant literature from 1966 to 1999 in a Medline search strategy limited to randomized clinical trials (RCTs). The results were inconclusive. The main difficulty when analyzing RCTs was related to inconsistencies in measuring treatment-outcome variables. In addition, treatment durations varied among studies, and treatment groups were compared with either untreated control groups or subjects undergoing other forms of treatment.

RCTs have been recommended as the standard for comparing alternative treatment approaches. To date, very few RCTs on treatment outcomes of functional jaw orthopedics have been published in the orthodontic literature. The difficulty in gathering many patients

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Abnormal mandibular growth and the condylar cartilage

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SUMMARY Deviations in the growth of the mandibular condyle can affect both the functional occlusion and the aesthetic appearance of the face. The reasons for these growth deviations are numerous and often entail complex sequences of malfunction at the cellular level.

The aim of this review is to summarize recent progress in the understanding of pathological alterations occurring during childhood and adolescence that affect the temporomandibular joint (TMJ) and, hence, result in disorders of mandibular growth. Pathological conditions taken into account are subdivided into (1) congenital malformations with associated growth disorders, (2) primary growth disorders, and (3) acquired diseases or trauma with associated growth disorders.

Among the congenital malformations, hemifacial microsomia (HFM) appears to be the principal syndrome entailing severe growth disturbances, whereas growth abnormalities occurring in conjunction with other craniofacial dysplasias seem far less prominent than could be anticipated based on their oftendisfiguring nature. Hemimandibular hyperplasia and elongation undoubtedly constitute the most obscure conditions that are associated with prominent, often unilateral, abnormalities of condylar, and mandibular growth. Finally, disturbances of mandibular growth as a result of juvenile idiopathic arthritits (JIA) and condylar fractures seem to be direct consequences of inflammatory and/or mechanical damage to the condylar cartilage.

Introduction

The size of the mandible, including the corpus, ramus, and condyle, as well as the timing and amount of condylar growth, vary considerably between individuals. Factors potentially contributing to this individual variation are the extent of masticatory action related to the consistency of the diet (Kiliaridis *et al.*, 1999) and, as shown recently (Van Erum *et al.*, 1997; Zhou *et al.*, 2005), genetic predisposition.

Distinct from even extreme cases of individual variation, the deviations from normality considered in this review constitute examples of abnormal mandibular and/or condylar growth that are related to truly pathological alterations. Based on their aetiology and time of appearance, they can be classified as (1) congenital malformations with associated growth disorders, (2) primary growth disorders, and (3) acquired diseases or trauma with associated growth disorders.

Congenital malformations with associated growth disorders

The most prevalent craniofacial malformation involving mostly unilateral condylar and ramal underdevelopment, as well as greatly variable abnormalities of the external and middle ear, is hemifacial microsomia [HFM; (Online Mendelian Inheritance in Man database of Johns Hopkins University: http://www.ncbi.nlm.nih.gov/sites/entrez?db=omim) OMIM 164210] with an estimated frequency of about 1/5000–6000 live births. Because of the similarity with the manifestations of Goldenhar syndrome that is characterized additionally by vertebral defects and epibulbar dermoids, the two conditions have been combined under the term oculo-auriculo-vertebral (OAV) spectrum (Gorlin *et al.*, 2001). Its aetiology seems to be heterogeneous. Genetic factors, in particular chromosomal anomalies such as deletions of 5p, 6q, 8q, 18q, and 22q; duplications of 22q; and trisomies 7, 9, 18, and 22, have been implicated with the OAV spectrum. On the other hand, anomalies similar to those of HFM and Goldenhar syndrome resulted from early foetal exposure to thalidomide or retinoic acid (Gorlin *et al.*, 2001). In fact, a HFM-like phenotype could be reproduced using triazine, an anti-cancer drug, in mice and thalidomide in monkeys (Poswillo, 1973). Poswillo (1973) suggested that haemorrhages at the anastomosis of the external carotid and stapedial artery were responsible for the anomalies that seemed to increase in severity with the extension of local tissue damage. However, there is also considerable overlap in manifestations of the OAV spectrum, the retinoic acid syndrome, and the DiGeorge syndrome (OMIM 188400), a condition attributed to the loss of the T-box transcription factor TBX1 due to chromosomal deletion 22q11.2 (Botto *et al.*, 2003; Packham and Brook, 2003). Common to all of these three entities are cono-truncal cardiovascular defects, which led Johnston and Bronsky (1995) to suspect that defective neural crest cell development could be the primary cause of HFM.

The extent of temporomandibular joint (TMJ) involvement in the OAV spectrum largely determines the timing and type of treatment (Caccamese *et al.*, 2006). Therefore, HFM is often classified based on the degree of TMJ dysmorphology

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Meta-analysis of skeletal mandibular changes during Fränkel appliance treatment

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SUMMARY The purpose of this study was to perform a meta-analysis of articles to verify the mandibular changes produced by the Fränkel-2 (FR-2) appliance during the treatment of growing patients with Class II malocclusions when compared with untreated growing Class II subjects.

The literature published from January 1966 to January 2009 was reviewed with search engines. A quality analysis was performed. The effects on primary end points were calculated with random-effect models. Heterogeneity was assessed using *Q* statistic and investigated using study-level meta-regression.

A total of nine articles were identified. The quality of the studies ranged from low to medium. Meta-analysis showed that the FR-2 was associated with enhancement of mandibular body length [0.4 mm/year 95 per cent confidence interval (CI) 0.182–0.618], total mandibular length (1.069 mm/year, 95 per cent CI 0.683–1.455), and mandibular ramus height (0.654 mm/year, 95 per cent CI 0.244–1.064). A consistent heterogeneity among studies was found for all the considered linear measurements.

The FR-2 appliance had a statistically significant effect on mandibular growth. Nevertheless, the heterogeneity of the FR-2 effects, the quality of studies, the differences in age, skeletal age, treatment duration, and the inconsistent initial diagnosis seem to overstate the benefits of the FR-2 appliance.

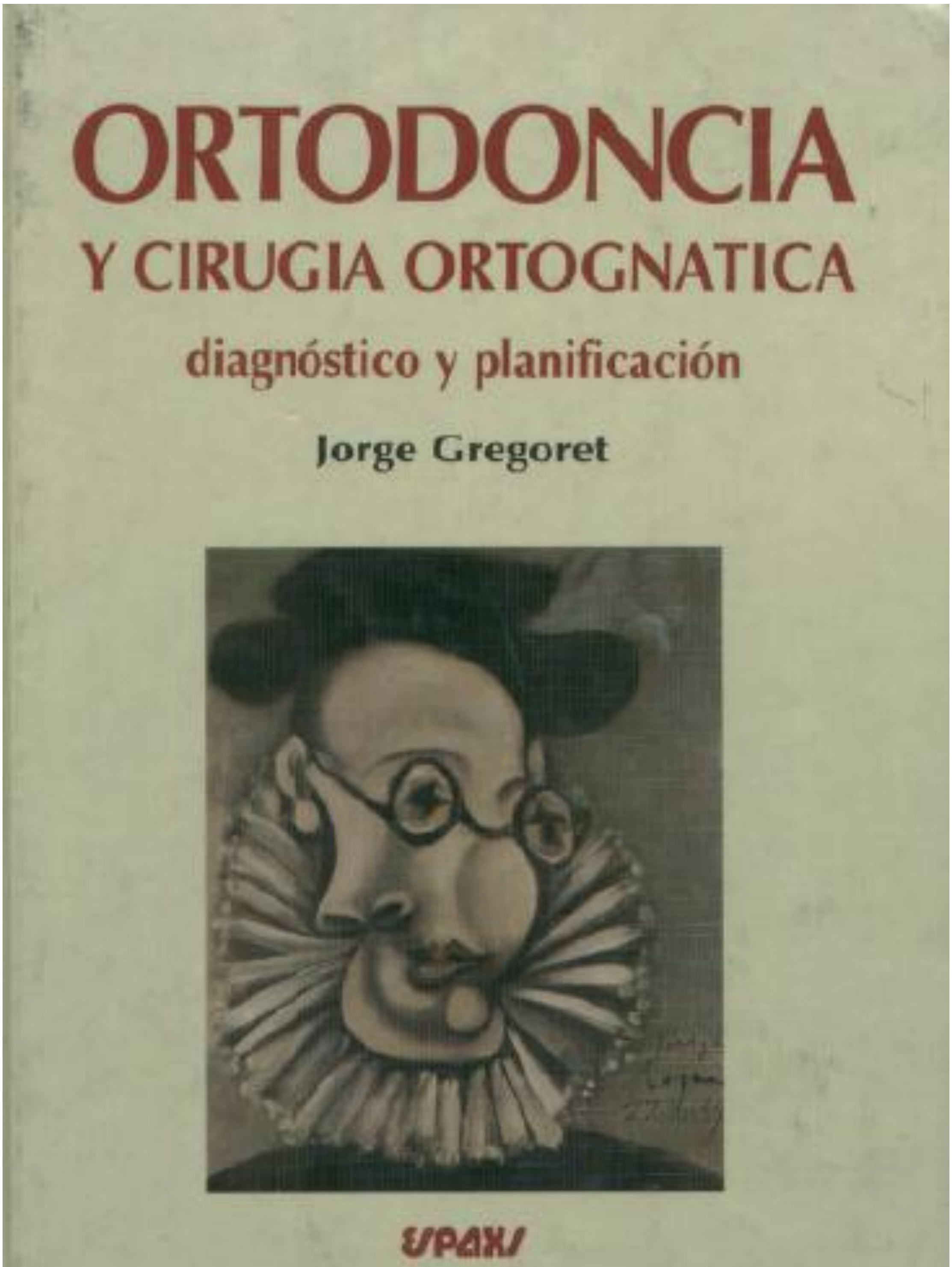
An evidence-based approach to the orthodontic outcomes of FR-2 appliance is needed, by selecting and comparing groups of children with the same cephalometric characteristics with and without treatment.

Introduction

Class II malocclusions occur in a variety of skeletal and dental configurations (Cozza *et al.*, 2006) among which the most common appears to be mandibular skeletal retrusion (McNamara, 1981; Pancherz *et al.*, 1997). A therapy aimed at enhancing mandibular growth is indicated in these patients.

Since the 1930s, a wide range of functional appliances designed to increase mandibular growth gained popularity in Europe and then throughout the rest of the world (McNamara *et al.*, 1996; McNamara and Brudon, 2001; Chen *et al.*, 2002; Cozza *et al.*, 2006). One of the most popular and well-characterized functional appliances is the functional regulator (FR-2; Fränkel, 1966, 1969a,b, 1973, 1983; Falck and Fränkel, 1989; Perillo *et al.*, 1996; Tulloch *et al.*, 1997, 1998; Johnston, 1998; Chen *et al.*, 2002). Unlike other functional appliances, the FR-2 has a mode of action based on orthopaedic principles that consider exercise and muscle training to be important factors in the normal development of osseous tissues (Fränkel, 1966, 1969a,b, 1973, 1983; Perillo *et al.*, 1996). A specific indication for FR-2 is represented by a Class II division 1 malocclusion associated with mandibular deficiency (Fränkel, 1983; Perillo *et al.*, 1996).

The FR-2 treatment approach has led to disparate outcomes in studies on humans (McNamara *et al.*, 1996; McNamara and Brudon, 2001; Chen *et al.*, 2002; Cozza *et al.*, 2006). Some authors (Reey and Eastwood, 1978; Luder, 1982; Pancherz, 1982, 2005; Birkebæk *et al.*, 1984; McNamara *et al.*, 1985, 1990; Haynes, 1986; Jakobsson and Paulin, 1990; Mamandras and Allen, 1990; Windmiller, 1993; Perillo *et al.*, 1996; Pancherz *et al.*, 1997; Tulloch *et al.*, 1997; Franchi *et al.*, 1999; Toth and McNamara, 1999; Tümer and Gültan, 1999; Baccetti *et al.*, 2000; Mills and McCulloch, 2000; De Almeida *et al.*, 2002; Basciftci *et al.*, 2003; Faltin *et al.*, 2003; Pangrazio-Kulbersh *et al.*, 2003; Cozza *et al.*, 2004) have suggested that mandibular growth can be increased, whereas others stated that mandibular length cannot be altered (Jakobsson, 1967; Vargervik and Harvold, 1985; Nelson *et al.*, 1993; Illing *et al.*, 1998; Chadwick *et al.*, 2001; Janson *et al.*, 2003; O'Brien *et al.*, 2003) with significant treatment effects restricted to dentoalveolar changes (Tulley, 1972; Robertson, 1983; McNamara *et al.*, 1985, 1990; Fränkel and Fränkel, 1989; Perillo *et al.*, 1996; Toth and McNamara, 1999; Chadwick *et al.*, 2001; McNamara and Brudon, 2001; De Almeida *et al.*, 2002; Cozza *et al.*, 2006).


ORTODONCIA
Y CIRUGIA ORTOGNATICA
diagnóstico y planificación
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Lip and tongue pressure in orthodontic patients

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SUMMARY The contribution of the force of the lips, cheeks, and tongue is of particular interest in planning treatment. Thus, the aim of this study was to determine if there are differences in lip and tongue pressure as a function of gender, age, Angle classification, characteristics of occlusion, and oral habits.

This cross-sectional study comprised 107 subjects (63 females and 44 males), between 7 and 45 years of age (median 15.2 years), seeking orthodontic treatment. The patients were characterized by the variables gender, age, Angle classification, the characteristics of the occlusion, and oral habits. Lip and tongue pressure were measured with a Myometer 160 and the obtained values were statistically analysed (Kruskal–Wallis and Mann–Whitney U-tests) to highlight possible significant differences between the groups.

There was a difference in lip pressure between males and females, between the Angle Classes, and between patients with various associated oral habits. Lip pressure was not significantly correlated with age or with occlusal characteristics. There was no evidence for a relationship between tongue pressure and any of the five considered variables. The findings of present study showed statistically significant differences in lip pressure between different orthodontic patients. There was a difference ($P = 0.004$) in lip pressure between Class I and Class II division 1 subjects. A higher lip pressure exists in males. Lip pressure in subjects with an open lip relationship was lower ($P = 0.026$) when compared with those with tongue interposition or with no particular habits. Lip pressure was also lower in subjects with lip interposition compared with those with tongue interposition.

Introduction

Bone is one of the hardest tissues of the body, although also very responsive to changes in environmental balance. The musculature plays a major role in this field (Jung *et al.*, 2003). It is generally also assumed that alveolar bone responds to external influences.

Most dental professionals accept the theory of Tomes (1873), who asserted that opposing forces or pressure from the lips and cheeks on one side and the tongue on the other, determine the position of the teeth (Posen, 1976; Mitchell and Williamson, 1978). The contribution of the forces of the lips, cheeks, and tongue are of particular interest to orthodontists in correct treatment planning. The technical skills and protocol that the orthodontist uses to assess these forces may determine the ultimate success of orthodontic treatment (Winders, 1962).

Nevertheless, the literature on this topic contains many contradictions. The aims of the present study were to evaluate whether there are statistically significant differences between lip pressure and tongue pressure, and to determine whether those differences are influenced by gender, age, Angle classification, characteristics of occlusion, and oral habits.

Subjects and methods

The peak lip and tongue pressure of 107 subjects (63 females and 44 males) between 7 and 45 years of age (median 15.2 years) was measured during maximum voluntary contraction. At the initial orthodontic consultation, an informed consent was obtained from the patients. They were classified into groups based on gender, age, Angle classification (occlusion of the first molars or the expected occlusion of the first molars in the case of primary teeth), the characteristics of the occlusion, and oral habits (Table 1).

Maximum lip and tongue pressure was measured with a Myometer 160 (MFT-Products, Matzendorf, Switzerland; Figure 1). This type of myometer, manufactured specifically for measurement of pressure or tension of the intra- and perioral muscles in the field of orthodontics, used in the study of Horn *et al.* (1995). The Myometer 160 contains a probe, which consists of two plates that are screwed together on one side. On the other side (probe tip), the two plates can be pushed towards each other. The applied force is measured by an electronic device installed between the plates and shown on a bar graph.

Lip pressure was measured by placing the thumb and forefinger on one side of the probe behind the electronic device to avoid interference with the measurements. The patient was told to occlude maximally, which inhibited biting on the probe. Two investigators (EDB and HL) were trained and calibrated in the use of the Myometer. The probe was held against the most prominent maxillary central incisor. The patient enclosed the probe tip with the lips and pressed the two plates towards each other as close as

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Myofunctional therapy and prefabricated functional appliances: an overview of the history and evidence

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ABSTRACT

Malocclusion represents the clinically observable endpoint of numerous genetic and environmental influences. Oral Myofunctional Therapy (OMT) aims to treat malocclusions by improving the oral environment through re-education of musculature and respiratory patterns. Although the concept of OMT has existed since the early part of the 20th Century, many of its purported benefits for the treatment of malocclusion remain undemonstrated in the scientific literature. However, a more recent application of OMT for the treatment of Obstructive Sleep Apnoea (OSA) suggests some benefits, although more research is needed to clarify this effect. Prefabricated functional appliances (PFAs) are sometimes advocated as part of myofunctional training programs. In the past decade, controlled clinical investigations have demonstrated that PFAs can improve Class II Division 1 malocclusions in compliant patients. Compared with traditional functional appliances, PFAs might be more cost effective; however, this must be balanced against compliance problems and evidence suggesting that other types of functional appliances might give better treatment results in a comparable time frame.

Keywords: Myofunctional Therapy, Myofunctional appliance, Prefabricated functional appliances, Orthodontics.

Abbreviations and acronyms: OMT = Oral Myofunctional Therapy; PFA = prefabricated functional appliance; OSA = Obstructive Sleep Apnoea; AHI = apnoea hypopnoea index; RCT = randomised controlled trial.

(Accepted for publication 20 March 2019.)

INTRODUCTION

Oral Myofunctional Therapy (OMT) has been defined as 'the treatment of dysfunctions of the muscles of the face and mouth, with the purpose of correcting orofacial functions, such as chewing and swallowing, and promoting nasal breathing'.[1] Since it was first proposed over a century ago, the role of OMT in orthodontic therapy has been hotly debated.[2,3]

Empirically, OMT appears to be enjoying popularity with many dentists at present. An online search for dentists registered with one OMT organization identified at least 80 Australian dental practices[4] and several other OMT courses are currently marketed. Considering the current level of interest in OMT within the dental profession, we have prepared a review of the available evidence concerning OMT as well as prefabricated functional appliances (PFAs).

This review will explore the aetiology of malocclusion, the historical development of OMT and consider the evidence to support OMT and PFAs. The materials used for this paper were gathered from relevant searches of PubMed and Google Scholar. References within articles that were not located in the search strategy were also searched. Case reports and uncontrolled studies were not considered. Although this review is non-systematic and the search strategy might have overlooked some relevant articles, it is consistent with the objective of providing an overview of the literature regarding OMT and PFAs.

THE AETIOLOGY OF MALOCCLUSION

The possible role of OMT in the treatment of malocclusion is closely related to the question of how a malocclusion develops. Unfortunately, a view that dichotomises the roles of environment and genetics emerged in the late 19th Century and persists today. In many respects, this debate has paralleled the wider discussion of 'nature versus nurture' in human development. Nevertheless, the literature to date suggests that malocclusions are aetiologically complex and that dogmatic viewpoints at either extremes are over-simplistic and fail to adequately explain the totality of the evidence.

SPECIAL ARTICLE

Orthodontics in 3 millennia. Chapter 9: Functional appliances to midcentury

Norman Wahl
Sequim, Wash

The history of the functional appliance can be traced back to 1879, when Norman Kingsley introduced the "bite-jumping" appliance. In the early 1900s, parallel development began in the United States and Europe in fixed and functional techniques, respectively, but the Atlantic Ocean was a geographic barrier that restricted the sharing of knowledge and experience in these philosophies. The only exception to this was the fixed functional appliance designed by Herbst. The monobloc, developed by Robin in 1902, is generally considered the forerunner of removable functional appliances, but the activator developed in Norway by Andresen in the 1920s was the first functional appliance to be widely accepted, becoming the basis of the "Norwegian system" of treatment. Both the appliance system and its theoretical underpinnings were improved and extended elsewhere in Europe, particularly by the German school led by Häupl, Bimler, and Balters. It would be after midcentury before functional appliances were reintroduced into American orthodontics. (Am J Orthod Dentofacial Orthop 2006;129:829-33)

For many years, the exclusive province of dentofacial orthopedics was Europe, while North America was firmly rooted in Angle's fixed-appliance philosophy, yet it was Norman W. Kingsley who first (1879) used forward positioning of the mandible in orthodontic treatment. Kingsley's removable plate with molar clasps might be considered the prototype of functional appliances, having a continuous labial wire and a bite plane extending posteriorly. As he described it, "The object was not to protrude the lower teeth, but to change or jump the bite in the case of an excessively retreating lower jaw." Edward H. Angle used a pair of interlocking rings, soldered to opposing first molar bands, much along the lines of today's mandibular anterior repositioning appliance (Fig 1), to force the mandible forward. The Oliver guide plane was another functional adjunct from this side of the Atlantic serving that purpose (Chapter 5).

As a result of studies on a dolphin's tail fin, Wilhelm Roux is credited as the first to study the influences of natural forces and functional stimulation on form (1883) (Wolff's law, Chapter 4). His work became the foundation of both general orthopedic and functional dental orthopedic principles. Later, Karl Häupl saw the potential of Roux's hypothesis and explained how functional appliances work through the activity of the orofacial muscles.[1]

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The monobloc

The first practitioner to use functional jaw orthopedics to treat a malocclusion was Pierre Robin (1902). His appliance influenced muscular activity by changing the spatial relationship of the jaws. Robin's monoloc was actually an adaptation of Ottolengui's removable plate, which, in turn, had been a modification of Kingsley's maxillary plate. It extended all along the lingual surfaces of the mandibular teeth, but it had sharp lingual imprints of the crown surfaces of both maxillary and mandibular teeth. It incorporated an expansion screw in the palate to expand the dental arches.

Robin designed his monobloc specifically for children with the glossoptosis syndrome (ectomorphic constitution, adenoid facies, mouth breathing, high palate, and other problems). It has since been named the Pierre Robin syndrome. Treatment would obviously require a total body approach, to include psychological support, muscular and breathing exercises, and lip closure, with the monobloc indicated to stimulate the activity of the facial musculature and to normalize the occlusion.

Myofunctional therapy

Alfred P. Rogers (1873-1959; Angle School, 1903), sometimes called the father of myofunctional therapy, also recognized the importance of the whole orofacial system. In addition, he was a strong proponent of the total-child approach and advocated muscular exercises to improve neck, head, and tongue posture and encourage nose breathing. Rogers grew up on the shores of

CASE REPORT

AJO-DO

Treatment with Twin-block appliance followed by fixed appliance therapy in a growing Class II patient

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A girl, aged 11 years 4 months, with a skeletal Class II pattern and a severe overjet (10 mm) was treated with a Twin-block appliance. After 9 months of appliance therapy, the skeletal Class II was overcorrected. After 26 months of retention, when the occlusion was stable and the growth rate was diminishing, fixed orthodontic appliances using temporary skeletal anchorage devices were initiated. The total active treatment time with fixed orthodontic appliances was 30 months. Posttreatment records after 18 months demonstrated excellent stability: a functional occlusion and a pleasing facial balance. Cone-beam computed tomography was used to visualize temporomandibular joint adaptations after the functional and fixed orthodontic therapies. (Am J Orthod Dentofacial Orthop 2016;150:847-63)

When a Class II malocclusion is due to a retrognathic mandible, positioning the mandible forward is believed to enhance its growth.[1-3] To correct a Class II skeletal pattern and a malocclusion, functional appliances have been widely used. Placement of a functional appliance results in displacement of the condyle in the glenoid fossa, stimulates growth of the condylar cartilage, and induces an accompanying lengthening of the mandible. The primary purpose of functional appliances such as the Twin-block is to modify or redirect mandibular growth to correct a skeletal discrepancy.

It has been reported that the efficiency of treatment of a retrognathic mandible strongly depends on the biologic responsiveness of the condylar cartilage.[1,2] During functional appliance treatment, changes in the mandibular condyle relative to mandibular advancement highly depend on the duration of functional therapy plus the direction, amount, and types of forces used.[4,5] However, it is still undetermined whether growth modification increases the total amount of mandibular growth or whether it only increases the rate of the genetically predetermined amount of mandibular growth.[6]

This article demonstrates successful orthodontic treatment using a Twin-block appliance and fixed orthodontic treatment for a girl who was 11 years 4 months of age with a severe skeletal Class II overjet (10 mm) caused by a retrognathic mandible. A normal occlusion and an improved profile were achieved after treatment. The use of cone-beam computed tomography (CBCT) allowed us to visualize the temporomandibular joint (TMJ) adaptations after functional therapy and fixed orthodontic treatment.

DIAGNOSIS AND ETIOLOGY

The girl was referred for an evaluation of orthodontic treatment. Her chief complaint was protrusion of her maxillary anterior teeth. The patient had a mesiofacial pattern and a Class II appearance. She had a protrusive upper lip, and when her lips touched in a rest position,

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All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and none were reported.
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Treatment effects produced by the Bionator appliance. Comparison with an untreated Class II sample

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SUMMARY The purpose of this retrospective investigation was to evaluate the dentoalveolar and skeletal cephalometric changes of the Bionator appliance on individuals with a Class II division 1 malocclusion. Lateral cephalograms of 44 patients were divided into two equal groups. The control group comprised 22 untreated Class II children (11 males, 11 females), with an initial mean age of 8 years 7 months who were followed without treatment for a period of 13 months. The Bionator group (11 males, 11 females) had an initial mean age of 10 years 8 months, and were treated for a mean period of 16 months. Lateral cephalometric headfilms were obtained of each patient and control at the beginning and end of treatment.

The results showed that there were no changes in forward growth of the maxilla in the experimental group compared with the control group. However, the Bionator treatment produced a statistically significant increase in mandibular protrusion, and in total mandibular and body lengths. There were no statistically significant differences in craniofacial growth direction between the Bionator group and the control group, although the treated patients demonstrated a greater increase in posterior face height. The Bionator appliance produced labial tipping of the lower incisors and lingual inclination of the upper incisors, as well as a significant increase ($P < 0.01$) in mandibular posterior dentoalveolar height. The major effects of the Bionator appliance were dentoalveolar, with a smaller significant skeletal effect. The results indicate that the correction of a Class II division 1 malocclusion with the Bionator appliance is achieved not only by a combination of mandibular skeletal effects, but also by significant dentoalveolar changes.

Introduction

A common strategy in the treatment of Class II division 1 malocclusions is frequently aimed at correcting or masking the skeletal discrepancy. Several types of functional appliance are currently in use for Class II treatment aimed at improving existing skeletal imbalances, arch form and orofacial function (Almeida *et al.*, 2002a, b) Among contemporary 'functional appliances', one of the most popular is the Bionator (Balters, 1964). Although few clinicians deny their clinical efficacy, proof of their growth-modifying effect remains elusive. Björk (1951), Harvold and Vargervik (1971), Nelson *et al.* (1993), and Pancherz (1984) stated that there is little evidence to support the claim that functional appliances significantly affect mandibular growth. However, a number of authors have suggested that mandibular growth can be increased with functional appliance treatment (Janson, 1977; Bolmgren and Moshiri, 1986; Op Heij *et al.*, 1989; Jakobsson and Paulin, 1990; DeVincenzo, 1991; Mills, 1991; Cura *et al.*, 1996; Ghafari *et al.*, 1998; Illing *et al.*, 1998). Other studies are in agreement that the most significant treatment effects are restricted to dentoalveolar changes (Tulley, 1972; Robertson, 1983; Chadwick *et al.*, 2001). The purpose of this retrospective research was to evaluate cephalometrically the possible effects of the Bionator appliance on the skeletal and dentoalveolar components in patients presenting with a Class II division 1 malocclusion, using an untreated control sample with similar malocclusions for comparison.

Materials and method

Sample selection

Control sample. The control sample was obtained from the files of the Orthodontic Department longitudinal growth study at the Bauru Dental School, University of São Paulo, Brazil and comprised 22 subjects (11 males, 11 females) with Class II division 1 malocclusions with an initial mean age of 8 years 7 months (range 8 years to 9 years 3 months) and a final mean age of 9 years 8 months (range 8 years 11 months to 10 years 6 months). This sample had no previous orthodontic treatment and was observed for a period of 13 months (range 10 months to 2 years 1 month).

Bionator sample. The 22 patients (11 males, 11 females) treated with the Bionator for a mean period of 16 months

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Dentoskeletal effects of class II malocclusion treatment with the modified Twin Block appliance

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Abstract

Background: The purpose of this study was to prospectively assess the dentoskeletal effect of a modified Twin Block appliance for treatment of class II malocclusions.
Material and Methods: Lateral cephalograms of 25 Class II malocclusion patients were compared to evaluate skeletal, dentoalveolar and soft tissue changes pre- and post-treatment with a modified Twin Block appliance. A total of 33 angular and linear variables were used for analysis. The differences were calculated at the start and end of treatment. The paired T test was performed to compare the cephalometric measurements before and after treatment.
Results: Compared the pre- and post- treatment measurements, there was a significant increase in SNB (P<0.001), CO-Gn (P<0.001), ANS-Me (P=0.001), Mandibular base (P<0.001), Lower 1 to NB (°) (P=0.004), Lower 1 to NB (mm) (P<0.001), and Z-angle (P=0.001) following functional therapy with modified Twin Block appliance. On the other hand, a significant decrease was observed in ANB (P<0.001), NA-Pog (P<0.001), overjet (P<0.001), and overbite (P=0.007), Upper 1 to palatal plane (P=0.007), UL-E-line (P<0.001), LL-E-line (P=0.001), and H-angle (P=0.002) after treatment with modified Twin Block appliance.
Conclusions: The modified Twin-Block improves facial esthetics in Class II malocclusion by a combination of changes in skeletal as well as dentoalveolar structures. The increase of mandibular unit length was observed to be due to a true mandibular growth not just a repositioning of the mandible. The modified appliance, however, did not show any superior effects in terms of less dental compensation compared to the conventional Twin–Block appliance.

***Key words:** Dentoskeletal effect, Modified Twin Block, Class II malocclusion.*

Introduction

Class II malocclusion is considered as one of the most prevalent craniofacial deformities. The efficiency of mechanotherapies and the addressed treatments time in this group of malocclusions are controversial topics (1) since skeletal class II malocclusion may be the result of sagittal mandibular deficiency, maxillary excess or a combination of these two (2,3).
Functional orthopedic appliances which are the acceptable growth modification mechanotherapies in skele-

CLINICIANS' CORNER

Clinical management of the acrylic splint Herbst appliance

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This article describes one variation in Herbst appliance design—the acrylic splint Herbst. Topics discussed include early fixed appliance treatment before Herbst therapy, impression taking, bite registration, and evaluation of appliance fabrication. The specifics of appliance delivery, including bonding of the maxillary appliance when indicated, are also discussed as are the techniques of appliance advancement and removal. (AM J ORTHOD DENTOFAC ORTHOP 1988;94:142-9.)

The Herbst appliance was introduced by E. Herbst in the early 1900s. After achieving some initial popularity,[1] this appliance remained infrequently used until it was reintroduced into the orthodontic literature in 1979 by Hans Pancherz.[2-8]

The Herbst bite-jumping mechanism is used in the correction of Class II malocclusion (Fig. 1). It extends from the region of the upper first molar to the region of the lower premolar teeth and works by prompting the lower jaw forward. The parts of the Herbst bite-jumping mechanism include the maxillary tube (sleeve), the mandibular plunger, and the axles (pivots) around which the tube and plunger rotate (Fig. 1). Screws attach the tube and plunger to the axles.

During the last few years, the original banded design of Pancherz has been modified in various ways. For example, stainless steel crowns have been substituted for orthodontic bands on the abutment teeth.[9-10] More recently acrylic splints have been used to carry the bite-jumping mechanisms on both the maxillary and mandibular dental arches[11-14] (Figs. 2 and 3).

In an effort to minimize the risk of decalcification and decay that was present with bonded splints, this description will emphasize the use of removable splints. In some instances the maxillary acrylic splint can be bonded in place, particularly if a rapid palatal expansion appliance or buccal tubes are used in conjunction with it. The mandibular splint is removable, almost never bonded. If poor compliance or neuromuscular problems such as cerebral palsy or polio are present, a cemented design with reinforced bands or stainless steel crowns may be indicated.

The clinical management of the acrylic splint Herbst appliance involves a series of steps that may include early fixed appliance treatment, impressions, construction, bite registration, delivery, patient instructions, advancement, and post-Herbst fixed appliance treatment.

Early fixed appliance treatment

Before placement of a Herbst appliance, many patients require repositioning of malposed teeth. The purpose of this first phase of orthodontic treatment is to decompensate the dental arches. This process is similar to the presurgical phase of orthodontic treatment that facilitates proper repositioning of the skeletal elements during surgery. During this first phase of treatment, retruded or overly erupted incisors may be flared or intruded. Also it is important to anticipate and establish a proper transverse relationship posteriorly before the lower jaw is brought into a forward position.

Pre-Herbst dental repositioning can be accomplished with an initial phase of fixed appliance therapy. For example, a utility arch[15-16] may connect the four incisors to the first permanent molar to correct vertical and horizontal discrepancies in the position of the anterior teeth. If transverse expansion is required, it may be accomplished before Herbst treatment through the use of an orthopedic maxillary expansion appliance.

Occasionally it is possible to combine the initial fixed appliance phase with Herbst treatment, particularly if the dental repositioning is limited to the maxillary arch. A rapid palatal expansion screw (Fig. 4) or buccal tubes (Fig. 5) can be incorporated into the maxillary splint. This allows simultaneous flaring of maxillary incisors, orthopedic midfacial expansion, and for-

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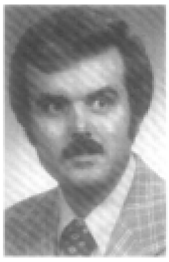

Dr. McNamara

The Fränkel appliance (FR-2): Model preparation and appliance construction

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This article describes the steps involved in the construction of a Fränkel FR-2 appliance, which is currently gaining popularity among orthodontists in the United States. Included is a description of proper impression technique and construction bite registration. The preparation of the working models by the clinician prior to sending them to a laboratory is outlined. In addition, a complete description of the fabrication of the FR-2 appliance is presented.

Key words: Functional regulator, Fränkel, construction, bite registration, impressions

The functional regulator[1-10] is a removable orthodontic appliance developed by Professor Rolf Fränkel of the German Democratic Republic. This appliance is used during the mixed and early permanent dentition stages to effect changes in anteroposterior, transverse, and vertical jaw relationships. The Fränkel appliance, as it is more commonly termed, has two main treatment effects. First, it serves as a template against which the craniofacial muscles function. The framework of the appliance provides an artificial balancing of the environment, thereby promoting more normal patterns of muscle activity. The second effect of the Fränkel appliance is its influence on skeletal and dental development. The Fränkel appliance removes muscle forces in the labial and buccal areas that restrict skeletal growth, thereby providing an environment which maximizes skeletal growth.

Four main types of functional regulator have been described by Fränkel (Tables I and II). Although Fränkel most often has advocated the use of the FR-1 appliance for the treatment of Class II malocclusion, we believe that the FR-2 appliance (which differs only slightly from the FR-1) is the appliance of choice in Class II treatment. The main difference between the two types of appliance is the addition of a lingual wire behind the upper incisors in the FR-2 which acts to prevent incisor tipping during treatment.

It has been only during the last three years that Fränkel has had the opportunity to use fixed appliances routinely in his clinic. Since his functional approach was developed more

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The twin block traction technique

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Summary. The twin block traction technique combines functional and traction systems to achieve rapid correction of arch relationships in Class II malocclusion. Improved facial balance indicates rapid skeletal adaptation in severe Class II skeletal malocclusions.

Twin blocks are upper and lower bite blocks which interlock at an angle of 45° causing a functional mandibular displacement. The concorde face bow combines extra-oral traction with intermaxillary traction by means of a horizontal intermaxillary elastic from the lower appliance to the facebow. If the patient fails to posture in the corrected occlusal position during the night this is compensated for by increased intermaxillary traction force. Reversed twin blocks are used for the treatment of selected Class III malocclusion.

Removable appliance technique

Active removable appliances use forces within the appliance, as opposed to extra-appliance muscular or functional forces.

Separate upper and lower removable appliances can only achieve significant correction of arch relationships if they incorporate extra-oral or intermaxillary traction, or produce functional mandibular displacement.

Extra-oral traction is used with removable appliances for distal movement of upper buccal segments but changes are slow and depend on a favourable growth response (McCallin, 1961).

Intermaxillary traction has been little used in the treatment of class II malocclusion with removable appliances mainly because the upward component of force displaces the lower appliance. Hotz (1960) used an expansion plate with a guide plane to ease the mandible forward in stages, and this was reinforced by intermaxillary elastics worn at night.

Schwarz (1956, 1966) designed removable appliances which corrected arch relationships by postural intermaxillary reaction and by intermaxillary traction. The Schwarz double plate attempted to combine the advantages of the activator and the active plate. The double plate produced excellent results but was not generally accepted, possibly because it restricted tongue space and jaw movement. Muller (1962) described a modification of the double plate which used wires to replace some of the acrylic in order to reduce the bulk.

The twin block traction technique

Twin blocks are a development of Pierre Robin's monobloc and the double plate of Schwarz. Twin blocks consist of upper and lower bite blocks which interlock at an angle of 45° causing a functional mandibular displacement to produce an intermaxillary reaction (Fig. 1).

The concorde facebow combines extra-oral traction with intermaxillary traction in such a way that the application of force in the lower arch is not restricted to the anchor molars and the unfavourable upward component of intermaxillary force is eliminated.

INDICACIONES Y EFECTOS TERAPEUTICOS DEL ACTIVADOR DE ANDRESEN. REPORTE DE UN CASO

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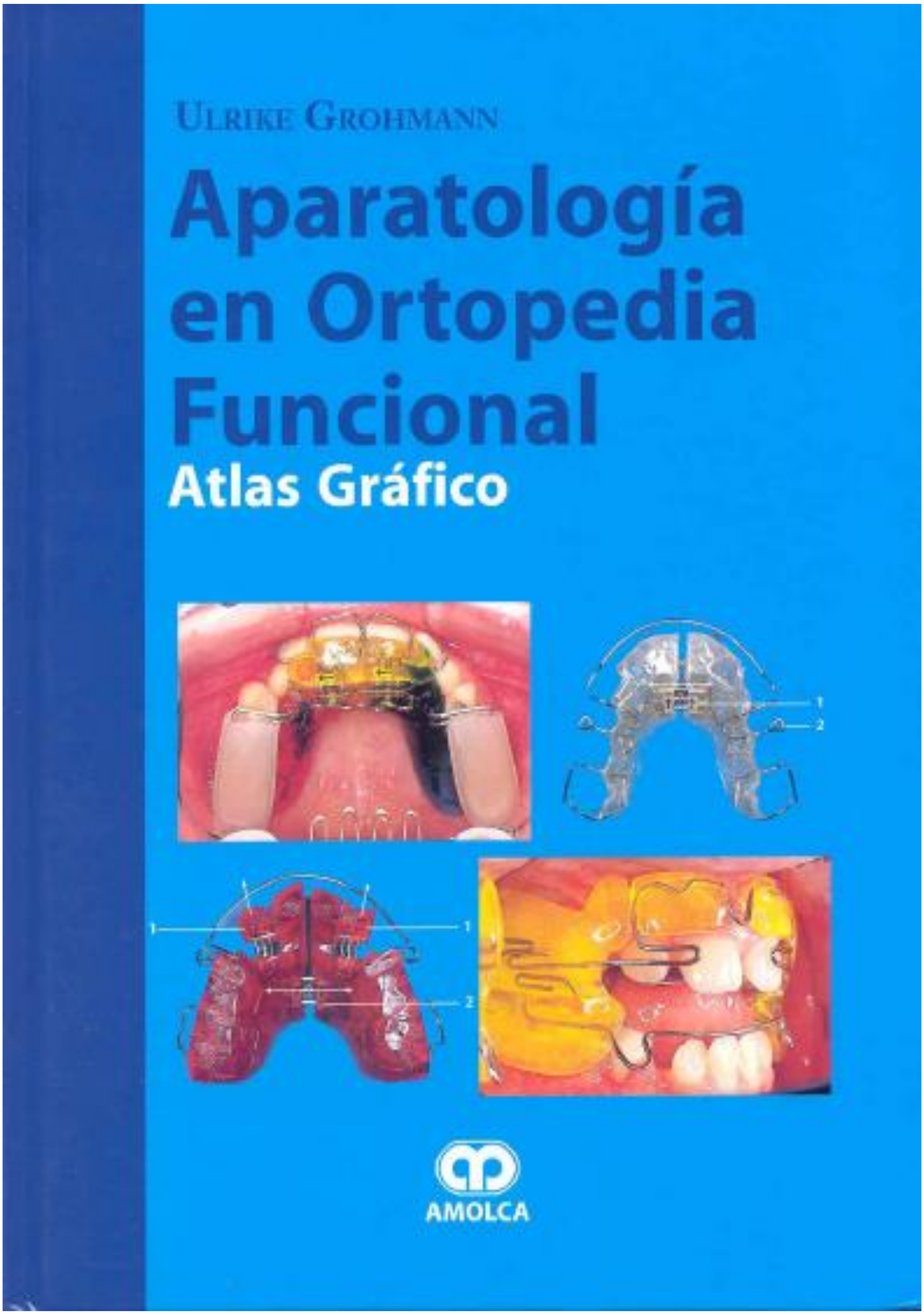
Resumen
En el tratamiento de las maloclusiones clase II por retrognatismo mandibular se han utilizado gran número de aparatos funcionales. El presente trabajo resume las principales características e indicaciones de uno de los Aparatos Funcionales más utilizado en Europa: el Activador de Andresen. Este estudio reporta un caso de una maloclusión Clase II División 1 tratado exitosamente con el Activador de Andresen.

Abstract
Authors have reviewed the principal characteristics of the most utilized functional dispositive in orthodontic in Europe: Andresen Activator. Factors like construction of the appliance, state of growth, direction of growth and necessity of cooperation determine the success of all functional appliances, inclusive the Andresen Activator. The aim of this study was to examine a case with Class II Division 1 malocclusion, which was treated with the Andresen Activator.

Key words: functional orthodontic, Activator

INTRODUCCION
Los aparatos funcionales constituyen herramientas terapéuticas capaces de modificar el esqueleto facial del paciente en crecimiento. Sin embargo, estos dispositivos ortopédicos también ejercen efectos ortodóncicos a nivel dentoalveolar, es por ello que su uso genera grandes controversias. Partiendo del hecho de que la función es inherente a todas las células, téjidos y órganos, uno de los principales objetivos de los aparatos funcionales consiste en aprovechar el estimulo de las fuerzas naturales y transmitirlo a zonas especificas del complejo cráneo facial(músculo y tejido óseo) a fin de generar los cambios deseados.(1)

En el tratamiento de las maloclusiones clase II por retrognatismo mandibular se han utilizado un gran número de aparatos funcionales. El Activador es uno de los aparatos pioneros de la Ortopedia Funcional. Fue utilizado originalmente por Andresen en 1908(2), partiendo de los conceptos propuestos por Kingsley (1880)(3) quien introdujo el principio de adelantar la mandibula en pacientes con retrognatismo mandibular, lo cual permitiria corregir la relación sagital maxilar sin inclinar anteriormente los incisivos inferiores. Sin embargo, no es sino hasta 1938, cuando Andresen se asocia con Häupl(4) y deciden bautizar este aparato funcional con el nombre de Activador debido a su capacidad para activar las fuerzas musculares. Según estos autores, el Activador inicia una actividad refleja miotática con contracciones isométricas capaces de inducir una adaptaciòn musculoesquelética que conlleva a un nuevo patrón de cierre mandibular. Esta adaptación involucra a los cóndilos, los cuales para adaptarse al avance mandibular, crecen en dirección posterosuperior a fin de mantener la integridad de las estructuras de la articulación temporomandibular(5). En la actualidad esta afirmación es aceptada por diversos autores, los cuales establecen que esta adaptación solo será posible con una reducida apertura bucal durante la construcción del aparato(1,6,7). Sin embargo, otros autores sostienen que el mecanismo de acción del activador, está influenciado por las propiedades viscoelásticas del músculo y el sobreestiramiento de los tejidos blandos, razón por la cual recomiendan


ULRIKE GROHMANN
Aparatología en Ortopedia Funcional
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Original Article

Morphometric analysis of long-term dentoskeletal effects induced by treatment with Balters bionator

Renato Bigliazzi[a]; Lorenzo Franchi[b]; André Pinheiro de Magalhães Bertoz[c]; James A. McNamara Jr[d]; Kurt Faltin Jr[e]; Francisco Antonio Bertoz[f]

ABSTRACT

Objective: To evaluate the long-term effects of the standard (Class II) Balters bionator in growing patients with Class II malocclusion with mandibular retrusion by using morphometrics (thin-plate spline [TPS] analysis).

Materials and Methods: Twenty-three Class II patients (8 male, 15 female) were treated consecutively with the Balters bionator (bionator group). The sample was evaluated at T0, start of treatment; T1, end of bionator therapy; and T2, long-term observation (including fixed appliances). Mean age at the start of treatment was 10 years 2 months (T0); at posttreatment, 12 years 3 months (T1); and at long-term follow-up, 18 years 2 months (T2). The control group consisted of 22 subjects (11 male, 11 female) with untreated Class II malocclusion. Lateral cephalograms were analyzed at the three time points for all groups. TPS analysis evaluated statistical differences (permutation tests) in the craniofacial shape and size between the bionator and control groups.

Results: TPS analysis showed that treatment with the bionator is able to produce favorable mandibular shape changes (forward and downward displacement) that contribute significantly to the correction of the Class II dentoskeletal imbalance. These results are maintained at a long-term observation after completion of growth. The control group showed no statistically significant differences in the correction of Class II malocclusion.

Conclusions: This study suggests that bionator treatment of Class II malocclusion produces favorable results over the long term with a combination of skeletal and dentoalveolar shape changes. (*Angle Orthod.* 2015;85:790–798.)

KEY WORDS: Functional jaw orthopedics; Class II malocclusion; Morphometric analysis; Thin-plate spline analysis

INTRODUCTION

Functional jaw orthopedics (FJO) at the pubertal spurt followed by fixed appliances is a viable therapeutic option in patients with Class II malocclusion associated with mandibular retrusion.[1] Among different FJO available to treat Class II malocclusion, the Balters bionator is a tooth-borne (passive) functional appliance designed and introduced by Balters in the 1960s.[2] The bionator moves the mandible anteriorly so that over time a new postural position of the lower arch

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ORTHODONTICS

Electromyographic evaluation in children orthodontically treated for skeletal Class II malocclusion: Comparison of two treatment techniques

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ABSTRACT

Objective: To compare the clinical efficacy of two techniques for fabricating a Bimler device by assessing the patient's surface electromyography (sEMG) activity at rest before treatment and six months after treatment.

Methods: Twenty-four patients undergoing orthodontic treatment were enrolled in the study; 12 formed the test group and wore a Bimler device fabricated with a Myoprint impression using neuromuscular orthodontic technique and 12 formed the control group and were treated by traditional orthodontic technique with a wax bite in protrusion. The "rest" sEMG of each patient was recorded prior to treatment and six months after treatment.

Results: The neuromuscular-designed Bimler device was more comfortable and provided better treatment results than the traditional Bimler device.

Conclusion: This study suggests that the patient group subjected to neuromuscular orthodontic treatment had a treatment outcome with more relaxed masticatory muscles and better function versus the traditional orthodontic treatment.

KEYWORDS
Class two skeletal; malocclusion; sEMG; TENS

Introduction

Class II malocclusion represents the most common dysgnathia in Caucasian patients. This class is characterized by a specific combination of dental, skeletal, and muscular functional features that together constitute a well-defined syndrome. From 1989 to 1994, the National Health and Nutrition Survey III (NHANES III) studied almost 14,000 people from various ethnic groups, collecting pertinent data about malocclusions in both children and adults in the United States (US). According to data from NHANES III, Class II is common in almost 11% of the US population and comprises at least 1/5 of all malocclusions (https://www.cdc.gov/nchs/nhanes/nhanes_products.htm). Within ethnic subgroups, Class II is present in 10.1% of Caucasians, 11.8% of African-Americans, and 6.5% of Latin/Hispanic populations. These data also suggest that a Class II skeletal pattern is the most common skeletal disharmony in both children and adults [1,2]. Moreover, Class II division I malocclusion is present at an incidence of 15–20% in the Caucasian population. This malocclusion is characterized by molar disto-occlusion and superior proalveolia. Skeletally, Class II generally occurs because of a mandibular deficit: Class II division 1 represents three-quarters of all orthodontic therapy referrals, but almost two-thirds of such patients have a normally positioned maxilla.

Dentoalveolar malocclusions represent a functional etiology and often have good therapeutic outcomes following treatment that, depending on the clinical features, includes orthopedic functional devices and/or fixed multi-bracket devices. Superior proalveolia is an acquired deviation of dentoalveolar growth resulting from parafunctional habits such as thumb-sucking, mouth breathing, and atypical swallowing. Its onset is usually at 3–5 years of age, when the shape of the maxilla is prone to simple alteration by parafunction or, therapeutically, according to the principals of the Moss functional matrix theory [3]. This malocclusion is of considerable orthodontic relevance and is treated with removable and/or fixed appliances. In contrast, skeletal dysgnathia is of genetic origin, and the functional imbalance that occurs secondarily appears to be a physiological adjustment to this defect rather than a cause [4–7]. In these patients, early treatment during growth is necessary to correct dysgnathia and re-establish

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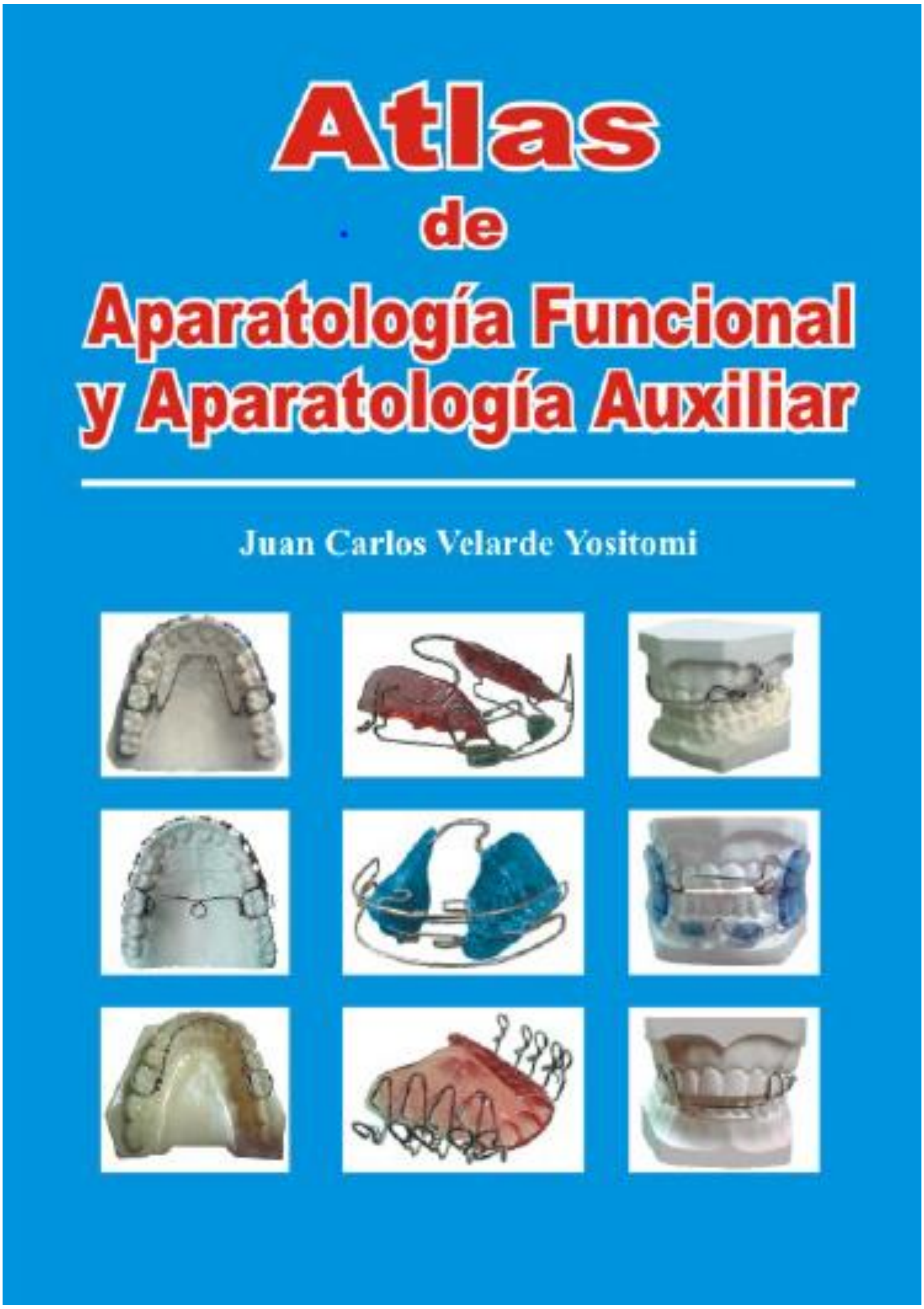
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CASE REPORT

AJO-DO

Severe Class II Division 1 malocclusion in an adolescent patient, treated with a novel sagittal-guidance Twin-block appliance

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Class II malocclusion is a challenging anomaly in orthodontic practice. Various types of functional appliances are used to correct Class II skeletal and occlusal disharmonies in growing patients, including the Twin-block. We used a modified sagittal-guidance Twin-block appliance combined with a fixed appliance and microimplant anchorage to treat a 13-year-old Chinese boy with a severe skeletal Class II malocclusion and mandibular retrognathia. Normal overjet and a Class I molar relationship were achieved because of the advancement of mandibular development, the restriction of maxillary growth, and dentoalveolar modifications in both the maxilla and the mandible. Favorable skeletal, dental, and soft tissue relationships were accomplished after 24 months of treatment. After 2 years of retention, the results remained stable. (Am J Orthod Dentofacial Orthop 2016;150:153-66)

Class II malocclusion is a challenging anomaly in orthodontic practice. The development of this malocclusion is due to mandibular retrognathia, maxillary protrusion, or both. It has been reported that retrusion of the mandible is the factor that most commonly contributes to a Class II malocclusion.[1]

Various types of functional appliances (eg, activator, bionator, Fränkel, and Herbst) are used for the correction of Class II skeletal and occlusal disharmonies in growing patients. Over recent decades, Twin-block appliances, which were originally developed by Clark[2] in the late 1970s, have increased in popularity.[3]

In this case report, we used a renovated sagittal-guidance Twin-block appliance (SGTB) combined with a fixed appliance and microimplant anchorage for the treatment of a 13-year-old Chinese boy with a severe skeletal Class II malocclusion and mandibular retrognathia.

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The SGTB consists of a bonded maxillary component and a mandibular removable counterpart. The maxillary component, which was bonded to the maxilla, has occlusal planes that cover the bilateral buccal dentition and often has a screw expansioner incorporated palatally. The mandibular piece, which is removable via Adams clasps on the first premolars and the first molars and ball clasps between the mandibular incisors for retention, has occlusal planes that bilaterally cover only the area of the premolars combined with a lingual acrylic pad that extends posteriorly. The angulation of the interface between the upper and lower occlusal planes is 70°. Two brackets are embedded into the buccal facade of the upper occlusal planes and serve as anchorage for the further placement of a maxillary partial fixed appliance.

The cephalometric analysis of Pancherz[4] showed that the normal overjet and a Class I molar relationship were achieved because of the advancement of mandibular development, the restriction of maxillary growth, and dentoalveolar modifications in both the maxilla and the mandible. Favorable skeletal, dental, and soft tissue relationships were accomplished after 24 months treatment. After 2 years of retention, the stability of the treatment was pronounced.

DIAGNOSIS AND ETIOLOGY

The patient was a 13-year-old Chinese boy with a convex facial profile, protrusive and everted lips, and a

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ORIGINAL ARTICLES

The twin block technique

A functional orthopedic appliance system

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THE OCCLUSAL INCLINED PLANE

The occlusal inclined plane is the fundamental functional mechanism of the natural dentition. Cuspal inclined planes play an important part in determining the relationship of the teeth as they erupt into occlusion.

Occlusal forces transmitted through the dentition provide a constant proprioceptive stimulus to influence the rate of growth and the trabecular structure of the supporting bone.

Fixed occlusal inclined planes have been used to alter the distribution of occlusal forces in animal experiments investigating the effects of functional mandibular displacement on mandibular growth and on adaptive changes in the temporomandibular joint.[1,2]

TWIN BLOCKS

Twin blocks are bite-blocks that effectively modify the occlusal inclined plane to induce favorably directed occlusal forces by causing a functional mandibular displacement (Fig. 1, *A* and *B*).

Upper and lower bite-blocks interlock at a 45° angle and are designed for full-time wear to take advantage of all functional forces applied to the dentition including the forces of mastication.

Wearing bite-blocks is rather like wearing dentures and patients can eat comfortably with the appliances in place.

In comparison to other functional appliances, occlusal inclined planes give greater freedom of movement in anterior and lateral excursion and cause less interference with normal function. The functional mechanism is very similar to the natural dentition. An additional motivating factor is that the appearance is noticeably improved when twin blocks are fitted and the absence of lip, cheek, or tongue pads places no restriction on normal function.

With twin blocks full functional correction of occlusal relationships can be achieved in many cases without the addition of any orthopedic or traction forces.

ORTHOPEDIC TRACTION

In cases in which the skeletal discrepancy is severe, the addition of an orthopedic traction system to support the action of occlusal inclined planes provides a versatile appliance technique that is effective in the treatment of a wide range of malocclusions.

The indications for treatment include maxillary protrusion, mandibular retrusion, and vertical growth discrepancies.

A functional orthopedic approach eliminates the uncertainty of treatment response that is sometimes associated with purely functional techniques. The technique achieves rapid correction of malocclusion even in cases with severe malocclusions that are unfavorable for conventional fixed or functional appliance therapy.

THE CONCORDE FACE-BOW

The twin block technique uses a new method of applying intermaxillary traction. The Concorde face-bow (Fig. 1, *C*) combines intermaxillary and extraoral traction by the addition of a recurved labial hook to a conventional face-bow. Intermaxillary traction is applied as a horizontal force from the labial hook to the lower appliance, eliminating the unfavorable upward

ORIGINAL ARTICLE

AJO-DO

Evaluation of cervical spine posture after functional therapy with twin-block appliances: A retrospective cohort study

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Introduction: It has been postulated that a change in cervical posture occurs as a consequence of forward repositioning of the mandible. Therefore, the objective of this study was to compare the cervical spine posture between subjects with and without functional appliance therapy. **Methods:** A retrospective cohort study was conducted with the use of pre- and post–functional therapy cephalograms of orthodontic patients. A total of 60 subjects was composed of 2 groups of 30 subjects each: those who underwent treatment with a twin-block (TB) functional appliance and a control group selected from the Bolton-Brush Growth Study. Three sagittal and 7 cervical vertebral parameters were compared between the groups. The Wilcoxon signed-rank test was used to compare pre- and postfunctional mean angular measurements. The Mann-Whitney *U* test was used to compare the mean changes in cervical parameters between the groups. **Results:** A significant difference existed between pre- and postfunctional SNB (P <0.001) and ANB (P <0.001) angles, showing a change in maxillomandibular relationship. Comparison of mean changes in angular measurements between the 2 groups showed a significant difference (P = 0.032) in the sella-nasion to odontoid process tangent (SN-OPT) angle. The SN-OPT angle predicted that the probability of developing an altered cervical posture with the TB appliance is 2.08 times greater than without the TB appliance. **Conclusions:** SN-OPT angle can predict a change in skeletal relationships after treatment with the TB functional appliance. The TB causes the craniocervical posture to be more upright. Subjects with reduced vertical dimensions have greater change in cervical posture. (Am J Orthod Dentofacial Orthop 2019;155:656-61)

Functional appliance treatment is considered to be a valuable strategy to overcome deficient growth of the mandible. In a study by Aslam et al,[1] Class II Division I malocclusion had a prevalence of 41% in patients who presented for orthodontic treatment. Many of these patients are growing, and numerous functional appliances can be prescribed for the correction of skeletal relationships. Functional appliances alter the activity of various muscle groups that influence the function and position of the mandible. This generates pressure from the stretch of muscles and surrounding soft tissues, which is also known as "viscoelastic stretch."[2] The redirection of forces produced by the appliance is transmitted to the underlying skeletal tissues and brings about orthodontic and orthopedic changes.[3]

The twin block (TB) was introduced by Clark[4] in 1982. Since then, it has become the most preferred functional appliance.[5] This removable appliance owes its increasing popularity to its uncomplicated design and ease of use.[5] It consists of separate upper and lower acrylic units which position the mandible forward through interlocking occlusal bite blocks.[3,5] The 2-piece design (Fig 1) facilitates speech and mastication and has proved to be associated with good patient compliance.[2,4] Extensive research on the skeletal and dental effects of the TB[6,7] has shown varied results.[8,9] The reason for these inconsistencies could be the difficulty in beginning treatment at the maximum growth spurt and using unreliable reference lines during cephalometric analysis.[10,11]

The association between the maxillomandibular relationships, the cervical column, and head posture has been investigated in the past.[7,12] As early as 1926, Schwarz[13] observed an association between the head posture and the jaw position. The head posture is claimed to be affected by the mode of breathing and

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ORIGINAL ARTICLE

Treatment effects of the twin block appliance: A cephalometric study

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A clinical study was undertaken to investigate the treatment effects of a modified Twin Block appliance. Pretreatment and posttreatment cephalometric records of 28 consecutively treated patients with Class II malocclusions were evaluated and compared with an age- and sex-matched sample of untreated Class II control subjects. The treatment group was considered to have severe skeletal Class II malocclusions and was treated using only the Twin Block appliance. Results indicated that mandibular growth in the treatment group was on average 4.2 mm greater than in the control group over the 14-month treatment period. In addition, some dentoalveolar effects in both arches contributed to the overjet correction. No statistically significant increase in the SN-mandibular plane angle occurred during treatment and, in general, the magnitude and direction of the skeletal changes were found to be quite favorable. (Am J Orthod Dentofacial Orthop 1998;114: 15-24.)

The purpose of this investigation was to determine the treatment effects of the Twin Block appliance and in particular to assess the extent to which the Twin Block appliance stimulates mandibular growth. This appliance, developed more than 20 years ago by Dr. William J. Clark[1-3] in Scotland, recently has gained popularity in North America. Very little has been reported in the scientific literature, however, with regard to the effectiveness of this widely used functional appliance.[4]

The most closely related study available was done by DeVincenzo,[5] who used an appliance similar to the Twin Block. This appliance consisted of maxillary and mandibular bite plates designed with a vertical interface between them. Both the DeVincenzo and the Twin Block appliances are based on the same principle as the protrusive functional appliances used on monkeys by McNamara[6-8] and others.[9,10]

Previous clinical studies of a variety of functional appliances have indicated varying degrees of success in achieving skeletal correction.[11-20] Because of the high percentage of patients presenting with Class II mandibular deficiency problems, orthodontists still are searching for the most effective means of stimulating mandibular growth preferentially. Barring surgical lengthening of the mandible to correct mandibular retrognathia, functional appliances seem to be the most direct approach to treatment of a mandibular deficiency problem.

The purpose of the current study was to evaluate cephalometrically the treatment effects of the Twin Block appliance.

MATERIAL AND METHODS

The treatment group consisted of 28 consecutively treated patients from the private practice of one of the authors. The criteria for case selection were as follows:

(1) skeletal Class II malocclusion in which the esthetic appearance of the patient improved when the mandible was postured forward;
(2) angle ANB of 5° or greater;
(3) full cusp Class II molar relationship on one side and end to end Class II molar relationship or greater on the other side.

The active treatment group included 11 boys and 17 girls ranging in age from 7 years 3 months to 11 years 1 month at the start of treatment (T1). The mean age of the treatment population was 9 years 1 month at T1.

The active treatment time with the Twin Block appliance ranged from 6 to 15 months. Although all patients were asked to wear their Twin Block appliances full-time, a wide range existed in the compliance.

Records for a control group of 28 untreated persons with Class II malocclusions were obtained from the Bur-

From the University of British Columbia and the University of Washington.
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OXFORD

Systematic Review

The effectiveness of the Herbst appliance for patients with Class II malocclusion: a meta-analysis

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Summary

Objective: To systematically investigate review in literature the effects of the Herbst appliance for patients with Class II malocclusion patients.
Method: We performed a comprehensive literature survey on PubMed, Web of Science, Embase, CENTRAL, SIGLE, and ClinicalTrial.gov up to December 2014. The selection criteria: randomized controlled trials or clinical controlled trials; using any kind of Herbst appliances to correct Class II division 1 malocclusions; skeletal and/or dental changes evaluated through lateral cephalograms. And the exclusion criteria: syndromic patients; individual case reports and series of cases; surgical interventions. Article screening, data extraction, assessment of risk of bias, and evaluation of evidence quality through GRADE were conducted independently by two well-trained orthodontic doctors. Consensus was made *via* group discussion of all authors when there is inconsistent information from the two. After that, sensitivity analysis and subgroup analysis were performed to evaluate the robustness of the meta-analysis.
Results: Twelve clinical controlled trials meet the above-mentioned criteria, and were included in this analysis. All included studies have eleven measures taken during both active treatment effect and long term effect periods, including four angular ones (i.e., SNA, SNB, ANB, mandibular plane angle) and seven linear ones (i.e. Co-Go, Co-Gn, overjet, overbite, molar relationship, A point-OLp, Pg-OLp) during active treatment effect period were statistically pooled. Meta-analysis and sensitivity analysis demonstrated that all these measures showed consistent results except for SNA, ANB, and overbite. Subgroup analysis showed significant changes in SNA, overbite, and Pg-OLp. Publication bias was detected in SNB, mandibular plane angle, and A point-OLp.
Conclusion: The Herbst appliance is effective for patients with Class II malocclusion in active treatment period. Especially, there are obvious changes on dental discrepancy and skeletal changes on Co-Gn. As to its long-term effects, more evidence is needed to draw conclusions.

Introduction

In patients with Class II malocclusion, large overjet and unfavorable profile may lead to negative feelings of self-image and self-esteem (1). Therefore, aesthetic improvement is a main treatment objective (2). Among all functional appliances for Class II malocclusion, the Herbst appliance is one of the most commonly used one. It was developed by Emil Herbst in the early 1900s and reintroduced by Pancherz in the late 1970 (3). As a bilateral telescope anchored to

ORIGINAL ARTICLE CE AJO-DO

Effectiveness of incremental vs maximum bite advancement during Herbst appliance therapy in late adolescent and young adult patients

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Introduction: The purpose of this research was to compare the effects of Herbst appliance therapy using incremental vs maximum advancement in late adolescent and young adult patients with Class II skeletal malocclusion. **Methods:** Forty-two patients with skeletal Class II malocclusion were treated with cast-splint Herbst appliances. The subjects were randomly allocated into 2 groups according to activation type: incremental advancement (IA) and maximum advancement (MA). Initial forward movement in the IA group was 4 to 5 mm and was followed by subsequent bimonthly advancements of 2 mm. Single-step advancement was achieved in the MA group until an edge-to-edge incisor relationship or an overcorrected Class I molar relationship was obtained. Total treatment times were 9.7 ± 1.1 months for the IA group and 9.5 ± 1.1 months for the MA group. Dental, skeletal, and soft tissue measurements were performed on lateral cephalograms taken just before and at the end of the Herbst appliance therapy. Statistical significance was set at $P \leq 0.05$. **Results:** All mandibular skeletal dimensions increased, and improvements of the sagittal maxillomandibular parameters were found in both groups. Protrusion and proclination of the mandibular incisors were greater in the IA group (95.90° ± 5.34°) compared with the MA group (92.04° ± 7.92°). Other dentoalveolar changes in both groups were intrusion of the maxillary first molars, and extrusion of the mandibular first molars and maxillary incisors. The mentolabial sulcus was flattened, soft tissue convexity was reduced, and forward movement of mandibular soft tissues was seen after Herbst therapy. **Conclusions:** Similar skeletal, dental, and soft tissue changes were obtained in both groups after Herbst therapy. Greater proclination and more protrusion of the mandibular incisors were found in the IA group. (Am J Orthod Dentofacial Orthop 2019;155:48-56)

It is challenging to solve the anteroposterior problems in adults with Class II malocclusion and mandibular retrognathism. The main goal of treatment for skeletal Class II patients is to obtain "lengthening" of the mandible.[1] The effects of functional appliances after cessation of growth are questionable, but similar condylar growth and glenoid fossa remodeling changes were observed after Herbst therapy in adults and adolescents.[2] So, Herbst therapy has become a popular method for skeletal Class II treatment in young adults recently.[2-4] The indication for adult Herbst treatment lies between orthodontic camouflage and orthognathic surgery in terms of mandibular skeletal effect.[5,6]

There are 2 options for the mode of advancement: incremental activation and maximum activation of the appliance. According to results of animal studies, the amount of initial activation is important.[7,8] Rabie and Al-Kalaly[8] stated that 4 mm of initial advancement causes significantly more favorable new bone formation on the condyle compared with a 2-mm initial activation. The minimal threshold of activation for achieving growth of the condyle and remodeling of the glenoid fossa was obtained after 4 mm of initial advancement. Significant increases were observed in the production of type II collagen, which is the main component of the cartilage of the mandibular condyle.[7-9] On the

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Dentoskeletal effects of Twin Block and Herbst appliances in patients with Class II division 1 mandibular retrognathy

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SUMMARY
OBJECTIVE: The aim of this study is to evaluate dentoskeletal effects of Herbst and Twin Block (TB) appliance therapies in Skeletal Class II malocclusion.
SUBJECTS AND METHODS: Herbst group consisted of 11 girls and 9 boys (mean age = 12.74 ± 1.43 years), TB group comprised of 10 girls and 10 boys (mean age = 13.0 ± 1.32 years), and control group included 9 girls and 11 boys (mean age = 12.17 ± 1.47 years). Mean treatment/observation times were 15.81 ± 5.96 months for Herbst, 16.20 ± 7.54 months for TB, and 15.58 ± 3.13 months for control group. Pre-treatment (T0) and post-treatment (T1) lateral cephalograms were traced using a modified Pancherz's cephalometric analysis. Inter-group differences were evaluated with one-way analysis of variance, and intra-group differences were assessed with paired samples *t*-test at the $P < 0.05$ level.
RESULTS: In control group, all sagittal and vertical skeletal measurements increased as a result of continuing growth. However, skeletal discrepancy and overjet remained unchanged. After functional appliance therapy, greater increases were recorded in TB group for all mandibular skeletal measurements compared with those in control group. Upper dental arch distalization and lower incisor protrusion were significant in Herbst group, compared with control. All face height measurements increased after functional appliance therapy.
IMPLICATIONS AND CONCLUSIONS: In TB group, the treatment effects were mainly due to mandibular skeletal changes. Both skeletal and dental changes contribute to Class II correction with Herbst appliance therapy. Herbst appliance may be especially useful in Skeletal Class II patients with maxillary dentoalveolar protrusion and mandibular dentoalveolar retrusion, whereas TB appliance may be preferred for skeletal mandibular retrognathy patients.

Introduction

Patient cooperation is one of the most important factors for successful functional appliance treatment. Need for cooperation is reduced with the use of fixed functional appliances. The Herbst appliance has gained widespread acceptance and is suggested to be the most effective appliance in correcting Class II malocclusions (Pancherz, 1997).

Although fixed functional appliances reduce the need for patient cooperation, they are tooth-borne appliances. On the other hand, removable functional appliances are more tissue borne and they are more likely to produce skeletal changes (Mills and McCulloch, 1998).

Twin Block (TB) can be worn for 24 hours and takes the advantage of all functional forces applied to dentition (Clark, 1982, 2002). Because of its small size, patients adopt it easily and speech disturbance is minimized (Mills and McCulloch, 1998).

The cast splint design is one of the most recent designs of Herbst appliance (Pancherz, 2003). Treatment effects of cast splint Herbst appliance (Ruf and Pancherz, 1998; Hägg *et al.*, 2002; Weschler and Pancherz, 2005; Martin and Pancherz, 2009) and TB appliance (Illing *et al.*, 1998; Lund and Sandler, 1998; Toth and Mcnamara, 1999; Bacetti *et al.*, 2000; Mills and McCulloch, 2000; Trenouth, 2000) were evaluated in adolescents.

Schaefer *et al.* (2004) compared the treatment effects of TB and Herbst appliances. They found that molar relationship and sagittal maxillomandibular discrepancy correction were greater for TB appliance. O'Brien *et al.* (2003a) evaluated the efficacy of Herbst and TB appliances and reported similar dental and skeletal effects. Because of high cooperation rates, they suggested that Herbst appliance could be a good treatment alternative for treating adolescents with Class II division 1 malocclusions (O'Brien *et al.*, 2003a). Neither of the studies included a control group to compare the effects of the appliances with an untreated sample.

In the literature, there seems to be a consensus on the effectiveness of both appliances, but the lack of comparable studies leaves questions regarding which appliance is more effective. Thus, the aim of this prospective clinical study is to compare the dentoskeletal effects of TB and Herbst appliances in patients with Class II division 1 mandibular retrognathy. The study also includes an untreated control sample to be compared with treatment groups.

Tratamiento de la Clase II mediante el Forsus

José Chaqués Asensi

J. Chaqués

RESUMEN

El Forsus (Forsus Fatigue Resistant Device™) es un dispositivo del tipo de la bielas intermaxilares que ha sido utilizado para la corrección de la Clase II con componente esquelético de grado moderado y relación oclusal moderada o grave. El Forsus representa un mecanismo fijo de fácil colocación y sencillo manejo clínico, que no precisa fase de laboratorio ni requiere un alto grado de colaboración por parte del paciente, y que muestra una tolerancia aceptable en pacientes de diversas edades. Por lo tanto, es un aparato que presenta ciertas ventajas en relación con otros diseños de bielas intermaxilares. En el presente artículo se describen su diseño y colocación, se analizan los aspectos relativos a sus indicaciones y manejo clínico, y se presentan dos casos clínicos que ilustran la secuencia terapéutica y los resultados obtenidos con este aparato.

Palabras clave: *Forsus. Tratamiento de la Clase II. Bielas intermaxilares.*

Treatment of the Class II with the Forsus appliance

J. Chaqués Asensi

ABSTRACT

The Forsus is a fixed intermaxillary appliance that has been used for the correction of the Class II with a limited skeletal component and a moderate to severe Class II dental malocclusion. The Forsus is a fixed easy to place and easy to handle device that does not need any laboratory fabrication procedure, does not require patient cooperation and is well tolerated in patients of different age groups. Therefore, is an appliance that shows certain advantages in comparison with other similar devices. In the present article the appliance design and placement are described, the aspects relative to the indications and clinical handling of the appliance are discussed and two case reports are presented in order to illustrate the therapeutic sequence employed as well as the results obtained with the use of the Forsus. **(Rev Esp Ortod. 2011;41:233-45).**

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Key words: *Forsus. Class II treatment. Intermaxillary devices.*

INTRODUCCIÓN

La corrección de la Clase II ha sido abordada en ortodoncia mediante diversos procedimientos que incluyen la aparatología funcional, las bielas intermaxilares, el uso de elásticos intermaxilares, las extracciones dentarias o el abordaje combinado de ortodoncia y cirugía ortognática. El uso de bielas intermaxilares tiene su precedente más relevante en el aparato de Herbst, reincorporado al arsenal terapéutico ortodóncico por Pancherz, Ruf y el grupo de Giessen[1-10]. Sin embargo, el aparato de Herbst en su versión clásica presenta algunas dificultades en la práctica clínica que pueden disuadir al ortodoncista de su uso rutinario. Entre ellas cabe mencionar que se trata de una estructura de gran rigidez que requiere un proceso de fabricación en el laboratorio y que necesita un ajuste muy preciso para su colocación. A ello hay que añadir que cualquier fractura o descementado de alguna de las partes exige una nueva fase de laboratorio tras desmontar toda o buena parte de la estructura[11,12]. Todo ello ha motivado que en el curso de las últimas décadas hayan aparecido en el panorama ortodóncico diversas variantes de bielas

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CASE REPORT

AJO-DO

Combined orthodontic-orthopedic treatment of an adolescent Class II Division 2 patient with extreme deepbite using the Forsus Fatigue Resistant Device

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Class II Division 2 malocclusion is often characterized by severe, traumatic deepbite with lingually inclined and overerupted incisors. Combined orthodontic-orthopedic treatment of this malocclusion is a challenging issue for orthodontists. This case report describes the combined orthodontic-orthopedic treatment of an adolescent Class II Division 2 patient with an extreme deepbite and a retrognathic mandible using the Forsus Fatigue Resistant Device. (Am J Orthod Dentofacial Orthop 2017;152:389-401)

A Class II Division 2 malocclusion is characterized by a severe deepbite with retroclination of the maxillary incisors.[1] The prevalence of Class II Division 2 malocclusions is relatively low compared with other malocclusions.[2] A strong genetic input exists with regard to the underlying skeletal pattern and dental anomalies in these patients.[2,3] It can be classified as a dental or a skeletal anomaly.[4] The dental Class II Division 2 anomaly is characterized by a balanced soft tissue facial profile with no skeletal discrepancy, but it has a Class II molar relationship and retroclined maxillary incisors with a deep overbite and an obtuse interincisal angle.[5] In addition to these intraoral findings, the skeletal group is characterized by reduced lower facial height, short upper lip, prominent chin, and small gonial angle.[6] The high lower lip line with associated resting pressure has been shown to be linked to retroclination of the maxillary incisors.[7]

Orthodontic treatment of Class II Division 2 malocclusions is recognized as difficult and prone to relapse.[7] The treatment modalities for this malocclusion include growth modification, dental compensation, and surgical-orthodontic therapy. The type of treatment depends on the patient's age and growth potential.[8] Because of specific morphologic characteristics, including retroclination of the maxillary incisors, a deepbite with a tendency for a brachycephalic facial pattern and a poor soft tissue facial profile, a nonextraction approach is recommended to treat Class II Division 2 malocclusions.[9]

During the functional orthopedic treatment protocol in growing patients, Class II Division 2 malocclusions are usually transformed into Class II Division 1 malocclusions by proclination of the maxillary incisors and then treated as a Division 1 malocclusion. In skeletal Class II Division 2 patients with a hypodivergent facial pattern, the deep overbite can be corrected, and facial esthetics can be improved by increasing the lower facial height, correcting lip redundancy, or increasing facial convexity.[8] Rather than intrusion of the incisors, extrusion of the posterior teeth is a favorable choice to correct the deep overbite resulting in increased lower anterior facial height caused by clockwise rotation of the mandible in growing patients.[8]

This case report describes the combined orthodontic-functional treatment outcomes of an adolescent Class II Division 2 patient with an extreme deepbite and a retrognathic mandible using a fixed functional appliance.

DIAGNOSIS AND ETIOLOGY

The patient, a 13-year-old boy, had a chief complaint of significantly retroclined maxillary anterior teeth and impingement of the palatal gingiva by the

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ORIGINAL ARTICLE

AJO-DO

Evaluation of stress changes in the mandible with a fixed functional appliance: A finite element study

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Introduction: The aim of this study was to evaluate the effects of a fixed functional appliance (Forsus Fatigue Resistant Device; 3M Unitek, Monrovia, Calif) on the mandible with 3-dimensional finite element stress analysis. **Methods:** A 3-dimensional finite element model of the mandible was constructed from the images generated by cone-beam computed tomography of a patient undergoing fixed orthodontic treatment. The changes were studied with the finite element method, in the form of highest von Mises stress and maximum principal stress regions. **Results:** More areas of stress were seen in the model of the mandible with the Forsus compared with the model of the mandible in the resting stage. **Conclusions:** This fixed functional appliance studied by finite element model analysis caused increases in the maximum principal stress and the von Mises stress in both the cortical bone and the condylar region of the mandible by more than 2 times. (Am J Orthod Dentofacial Orthop 2015;147:226-34)

The aim of orthodontic treatment of children with malocclusions is to produce a well-balanced facial profile and an acceptable occlusion. Despite good treatment planning and patient selection, facial esthetics may not be ideal, and this can be compounded by relapse after an initially successful treatment. Dentofacial orthopedists believe that functional appliances train patients in maintaining correct oral and tongue postures. In the treatment of Class II malocclusion, an early phase of functional appliance treatment is commonly used to simplify subsequent therapy and to optimize the development of the facial skeleton.

McNamara[1] reported mandibular retrusion as the most common characteristic of Class II malocclusion. Class II Division 1 malocclusions with mandibular deficiency have been treated for more than a century with different types of functional appliances. Woodside et al,[2] Stockli and Willert,[3] Vargervik and Harvold,[4] and Ruf and Pancherz[5] stated that typical muscular forces are generated by altering the mandibular position sagittally and vertically, resulting in orthodontic and orthopedic changes. The pressure created by stretching of the muscles and soft tissues is transmitted to the dental and skeletal structures, moving the teeth and modifying growth.

Many removable functional appliances, such as activator, bionator, Fränkel, and Twin-block, have been used to correct Class II Division 1 malocclusions; however, few fixed functional appliances have been used. These fixed functional appliances for sagittal advancement of the mandible have certain advantages over removable functional appliances, such as less dependence on patient compliance, and these can be used concurrently with fixed mechanotherapy, thereby reducing treatment duration.[3] Fixed functional appliances also enhance mandibular growth and tend to produce more horizontal condylar growth compared with removable appliances.[6-8]

The theoretical basis of functional treatment in general is the principle that a new pattern of function

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ORIGINAL ARTICLE
AJO-DO

Three-dimensional treatment outcomes in Class II patients treated with the Herbst appliance: A pilot study

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Introduction: The aims of this study were to analyze 3-dimensional skeletal changes in subjects with Class II malocclusion treated with the Herbst appliance and to compare these changes with treated Class II controls using 3-dimensional superimposition techniques. **Methods:** Seven consecutive Herbst patients and 7 Class II controls treated with Class II elastics who met the inclusion criteria had cone-beam computed tomographs taken before treatment, and either after Herbst removal or at posttreatment for the control subjects. Three-dimensional models were generated from the cone-beam computed tomography images, registered on the anterior cranial bases, and analyzed using color maps and point-to-point measurements. **Results:** The Herbst patients demonstrated anterior translation of the glenoid fossae and condyles (right anterior fossa, 1.69 ± 0.62 mm; left anterior fossa, 1.43 ± 0.71 mm; right anterior condyle, 1.20 ± 0.41 mm; left anterior condyle, 1.29 ± 0.57 mm), whereas posterior displacement predominated in the controls (right anterior fossa, –1.51 ± 0.68 mm; left anterior fossa, –1.31 ± 0.61 mm; right anterior condyle, –1.20 ± 0.41 mm; left anterior condyle, –1.29 ± 0.57 mm; $P < 0.001$). There was more anterior projection of B-point in the Herbst patients (2.62 ± 1.08 mm vs 1.49 ± 0.79 mm; $P < 0.05$). Anterior displacement of A-point was more predominant in the controls when compared with the Herbst patients (1.20 ± 0.53 mm vs –1.22 ± 0.43 mm; $P < 0.001$). **Conclusions:** Class II patients treated with the Herbst appliance demonstrated anterior displacement of the condyles and glenoid fossae along with maxillary restraint when compared with the treated Class II controls; this might result in more anterior mandibular projection. (Am J Orthod Dentofacial Orthop 2013;144:818-30)

Treatment of Class II malocclusions is a common challenge for orthodontists in the United States. Approximately one third of all patients have a Class II Division 1 malocclusion.[1,2] Mandibular retrognathism is the primary etiologic factor in most of those patients.[3,4] Functional appliances have been shown to be effective in correcting Class II malocclusions by decreasing overjet and achieving Angle Class I canine and molar relationships.[3-7] Eliminating patient compliance factors and delivering continuous forces give fixed functional appliances a distinct treatment advantage compared with removable appliances. Many studies have reported the greatest anteroposterior improvements in mandibular projection when using fixed Herbst functional appliances.[3,4,7-12]

Functional appliances, such as the Herbst, have been purported to improve mandibular projection, consequently improving the underlying skeletal discrepancies.[7,8,10,13] However, the available data that examine the extent of skeletal vs dentoalveolar adaptation in Class II correction with functional appliances are controversial.[5,6,13,14] The skeletal component of Class II correction has been reported to be from 13% to 85%.[5,11,14-21] Variations in reported skeletal changes are due to a number of factors ranging from physiologic and anatomic inconsistencies in the study subjects to limitations in the study methodologies.

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Clinical Management of the Herbst Occlusal Hinge Appliance

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Variations of the Herbst* appliance[1,2] fall into two basic categories: fixed and removable. Studies have found similar clinical results, although the fixed appliances seem to produce a slightly greater mandibular growth effect and less lower incisor proclination.[3,4] The major advantage of the removable appliances is the reduced likelihood of loosening or breakage,[5] while their main disadvantage is the need for patient cooperation.

*Registered trademark of Dentaurum, Inc., 10 Pheasant Run, Newtown, PA 18940.

This article describes a new version of the removable acrylic-splint Herbst appliance, called

Fig. 1 Herbst Occlusal Hinge (HOH) appliance. Upper splint is combined with optional expansion screw and lingual arms.

ORIGINAL ARTICLE CE

Skeletal and dentoalveolar effects of Twin-block and bionator appliances in the treatment of Class II malocclusion: A comparative study

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Introduction: The purpose of this study was to evaluate the skeletal and dentoalveolar effects of the Twin-block and bionator appliances in the treatment of Class II Division 1 malocclusions. **Methods:** Fifty-five girls from North India with Class II Division 1 malocclusion and the same physical growth maturation status were selected for the study. The subjects were divided among a Twin-block group (n = 25), a bionator group (n = 20), and a control group (n = 10). Pretreatment and posttreatment lateral cephalometric radiographs of the treatment group subjects, and prefollow-up and postfollow-up radiographs of the control group subjects, were traced manually and subjected to the pitchfork analysis. **Results:** Statistical software was used for 1-way analysis of variance and multiple comparisons (post-hoc test, Bonferroni). A P value of .05 was considered statistically significant. Neither the Twin-block nor the bionator appliance significantly restricted forward growth of the maxilla ($P = .476$). Mandibular growth in the Twin-block subjects was significantly greater than in controls ($P = .005$). Mandibular growth was comparable in the control and the bionator subjects. Molar correction, overjet reduction, and proclination of the mandibular incisors were significantly greater ($P = .000$) in the treated subjects compared with the controls. **Conclusions:** Both the Twin-block and bionator appliances were effective in correcting molar relationships and reducing overjets in Class II Division 1 malocclusion subjects. However, the Twin-block was more efficient than the bionator in the treatment of Class II Division 1 malocclusion. (Am J Orthod Dentofacial Orthop 2006;130:594-602)

Class II malocclusions can manifest in various skeletal and dental configurations.[1-5] Most Class II patients have a deficiency in the anteroposterior position of the mandible.[6] Several treatment options are available for managing Class II problems, and functional appliances have been used for many years in the treatment of Class II Division 1 malocclusions.[7-12] Several varieties of functional appliances are currently in use that aim to improve skeletal imbalances. Alteration of maxillary growth, possible improvement in mandibular growth and position, and change in dental and muscular relationships are the expected effects of these functional appliances. It has been claimed that the forward growth of the maxilla can be inhibited,[13-15] redirected,[16] or unaffected[17-19] by functional appliances. The effect of functional appliances on mandibular growth is controversial. Some authors suggested that mandibular growth can be increased with functional appliance treatment,[20-24] but others believe the appliances have no real effect on mandibular length.[25,26] However, most researchers agree that the appliances produce retroclination of the maxillary incisors[10,27,28] and proclination of the mandibular incisors.[29,30] There is no consensus on how the molar correction occurs.

Two of the more popular functional appliances used today are the Balters' bionator[8,31] and Clark's Twin-block.[32] Few studies have compared the effects of these appliances. Both are tooth-borne, but the Twin-block is designed for full-time wear to take advantage of all functional forces applied to the dentition, including the forces of mastication. The purpose of the study was to evaluate the skeletal and dentoalveolar effects of the Twin-block and bionator appliances in the correction of Class II Division 1 malocclusions.

MATERIAL AND METHODS

The subjects for this study were selected from the Orthodontic Clinic, Division of Orthodontics, Department of Dental Surgery, All India Institute of Medical Sciences, New Delhi; 55 girls from North India having the same cervical vertebrae maturation index were

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Review Article

Cephalometric Facial Soft Tissue Changes with the Twin Block Appliance in Class II division 1 Malocclusion Patients

A Systematic Review

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ABSTRACT

Objective: To evaluate facial soft tissue changes after the use of the twin block appliance in Class II division 1 malocclusion patients.

Materials and Methods: Several electronic databases (PubMed, MEDLINE, MEDLINE In-Process & Other Non-Indexed Citations, Cochrane databases, EMBASE, Web of Science, and LILACS) were searched with the help of a senior health-sciences librarian. Abstracts that appeared to fulfill the initial selection criteria were selected by consensus, and the original articles were retrieved. The article references were hand-searched for possible missing articles. Clinical trials that assessed facial soft tissue changes with the use of the twin block appliance without any surgical intervention or syndromic characteristics were considered. A comparable untreated control group was required to factor out normal growth changes.

Results: Two articles fulfilled the selection criteria and quantified facial soft tissue changes. Although some statistically significant changes in the soft tissue profile were found, the magnitude of the changes may not be perceived as clinically significant. Changes produced in the upper lip seem to be controversial, although the study with sounder methodological quality did not report significant changes. No change in the anteroposterior position of the lower lip and the soft tissue menton or improvement of the facial convexity was found.

Conclusions: Three-dimensional quantification of the soft tissue changes is required to overcome current limitations in our understanding of the soft tissue changes obtained after the use of the twin block appliance in Class II division 1 malocclusion patients.

KEY WORDS: Functional appliances; Soft tissue; Profile; Facial changes; Twin block

INTRODUCTION

Different removable functional appliances have been used to treat patients with Class II division 1 malocclusions. Although one of the main reasons for lay persons to undergo orthodontic treatment is esthetic improvement,[1,2] of the multitude of reports evaluating the skeletal and dental changes produced by removable functional appliances, only a relatively small proportion have analyzed the soft tissue changes.

The twin block appliance is the most popular functional appliance in the United Kingdom.[3] It was first introduced by Clark in 1988[4] and consists of two separate, upper and lower, removable plates with acrylic blocks trimmed to an angle of 70 degrees. These separate plates make the twin block appliance different in comparison with other removable functional appliances, which are basically monoblocks. Theoretically, this plus a less bulky appearance would increase patient acceptance of the appliance. Patients would also have more freedom in their mandibular movements. All these considerations could conceptually produce different treatment results compared with the removable functional monoblocks.

Several studies have evaluated the soft tissue changes produced by the twin block.[5–14] Although

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ORIGINAL ARTICLE CE

AJO-DO

Perceived facial changes of Class II Division 1 patients with convex profiles after functional orthopedic treatment followed by fixed orthodontic appliances

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Introduction: The aim of this research was to investigate the perceived facial changes in Class II Division 1 patients with convex profiles after functional orthopedic treatment followed by fixed orthodontic appliances. **Methods:** Pretreatment and posttreatment profile photographs of 12 Class II Division 1 patients treated with activators, 12 Class II Division 1 patients treated with Twin-block appliances, and 12 controls with normal profiles treated without functional appliances were presented in pairs to 10 orthodontists, 10 patients, 10 parents, and 10 laypersons. The raters assessed changes in facial appearance on a visual analog scale. Two-way multivariate analysis of variance was used to evaluate differences among group ratings. **Results:** Intrarater reliability was strong in most cases (intraclass correlation coefficients, >0.7). The internal consistency of the assessments was high (alpha, >0.87), both within and between groups. The raters consistently perceived more positive changes in the Class II Division 1 groups compared with the control group. However, this difference hardly exceeded 1/10th of the total visual analog scale length in its highest value and was mostly evident in the lower face and chin. No significant differences were found between the activator and the Twin-block groups. **Conclusions:** Although the raters perceived improvements of the facial profiles after functional orthopedic treatment followed by fixed orthodontic appliances, these were quite limited. Thus, orthodontists should be tentative when predicting significant improvement of a patient's profile with this treatment option. (Am J Orthod Dentofacial Orthop 2017;152:80-91)

Class II malocclusions have high prevalences in the population and are evident in a significant percentage of patients seeking orthodontic treatment.[1] A common treatment option, especially for growing skeletal Class II patients with a convex profile due to a retrognathic mandible, involves functional orthopedic treatment aiming to enhance mandibular growth.[2] Activator and Twin-block are 2 popular functional appliances of this type.[2,3]

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Previous studies that evaluated the soft tissue response to activator and Twin-block treatment using cephalometric measurements reported improvement of facial profiles after functional treatment.[4-7] A recent systematic review on this topic concluded that skeletal effects are minimal when natural growth is taken into account, but there are significant dentoalveolar and soft tissue changes.[2] However, the clinical impact of these changes is still questionable, even regarding soft tissues.

Improving facial appearance is an important goal of contemporary orthodontic treatment and a main reason for seeking treatment. Thus, patient satisfaction is closely related to improvement of the facial esthetic parameters.[8] Patients with a Class II skeletal pattern usually have increased facial convexity and retruded positions of the mandibular hard and soft tissues. These patients seek orthodontic treatment mainly to improve their facial appearance and consequently their self-esteem and quality of life.[9]

The definitions of beauty and attractiveness are complex and highly subjective. Probably, what laypersons

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Research

Effective temporomandibular joint growth changes after stepwise and maximum advancement with Twin Block appliance

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A R T I C L E I N F O

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A B S T R A C T

Background: This study was designed to evaluate the "effective" temporomandibular joint changes (the sum of condylar modeling, glenoid fossa modeling, and condylar position changes within the fossa) and their influence on mandibular rotation in Class II Division 1 malocclusion cases treated with Twin Block appliance using a maximum and stepwise advancement approach.
Methods: Sixty Class II Division 1 cases with normal growth patterns in the age group of 12 to 14 years were treated with the Twin Block appliance and randomly assigned to one of two groups: 1) maximum advancement ($n = 30$); and 2) stepwise advancement ($n = 30$). The Bolton Standards served as a control group. Lateral head films were obtained before treatment and after successful treatment (mean 1 year).
Results: Compared with the control groups, both treatment groups showed significant vertical growth changes. Sagittal growth direction was posterior with maximum advancement and anterior with stepwise advancement. Resultant mandibular rotation was in the anterior direction and was greater with stepwise advancement.
Conclusions: Myofunctional therapy after maximum and stepwise advancement with the Twin Block appliance showed a favorable effect in the temporomandibular joint region. Stepwise advancement showed greater vertical growth and more favorable anteriorly directed horizontal growth in the temporomandibular joint region on a short-term basis.

1. Introduction

The use of functional appliances in correcting Class II malocclusion with mandibular deficiency is an established modality of treatment. Although various randomized trials have shown little improvement after functional therapy compared with controls over a long period [1–3], studies in the past decade have been able to show consistent beneficial temporomandibular joint (TMJ) changes [4–12]. These beneficial effects were especially prominent with stepwise advancement of the mandible [13]. The other beneficial effects sited by proponents of this method include improvement in patient comfort with a greater likelihood of maintaining correct appliance position during sleep, and better patient compliance [14–16].

Few studies have investigated the clinical effects of different amounts of protrusive bite activation in functional appliances, with differing results [3,14,17,18]. Almost all of the studies have compared the treatment results cephalometrically, but none have focused specifically on temporomandibular growth adaptations after stepwise advancement with one of the most popular functional appliances today: the Twin Block appliance [19].

In the assessment of TMJ changes, use of classic reference points, such as the condylion and the articulare, has been shown to be inadequate [20]. Problems with these points can be overcome by a method described by Creekmore [21] for effective TMJ changes, which include summation of condylar remodeling, glenoid fossa remodeling, and positional changes of the condyle within the fossa.

The aims of the present investigation were to analyze and compare the effective TMJ changes and mandibular rotations in Class II patients after stepwise and maximum advancement of the mandible using the Twin Block appliance.

2. Methods and materials

The total sample consisted of 60 patients in the age group of 12 to 14 years (28 boys; 32 girls). They were randomly assigned to one of two groups: 1) maximum advancement group (30 patients

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Case Report

Early treatment outcomes of class II malocclusion with twin-block facial profile and cephalometric changes

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ABSTRACT

Esthetic improvement is highly valued by patients seeking orthodontic treatment. Subjects with a class II malocclusion are a good example of patients who seek treatment primarily for esthetic improvement. A young growing child with convex profile due to a small, retropositioned mandible, normal midface and lower tip trap is more suitable for functional appliance treatment. Functional appliances encourage adaptive skeletal growth by maintaining the mandible in a corrected forward position for a sufficient period of time to allow adaptive skeletal changes to occur in response to a functional stimulus. The aim of this article is to describe two cases of class II malocclusion in late mixed dentition period treated with twin-block. The cephalometric and facial profile changes have been discussed.

Keywords: *Class II malocclusion, functional appliance, twin-block.*

INTRODUCTION

'The functional matrix theory of Moss supports the premise that function modifies anatomy'. The form and function concept steadfastly remains the basic concept of functional therapy. The objective is to promote harmonious facial growth by changing the functional muscle environment around the developing dentition.[1]

A wide range of functional/orthopedic appliances is available for the correction of class II skeletal and occlusal disharmonies (e.g. Bionator, FR-2 of Fränkel, fixed, and removable Herbst appliances). Among these, the twin-block originally developed by William J. Clark of Fife, Scotland, has gained increasing popularity during the last decade. Twin-block appliance induces supplementary lengthening of the mandible by stimulating increased growth at the condylar cartilage.

The appliance consists of maxillary and mandibular acrylic plates with bite blocks that posture the mandible forward on closure.[2] Unlike one-piece functional appliances, twin-block has two separate, unattached upper and lower bite block components—actually two appliances which work together as one. Functional appliance has definite advantages in the treatment of patients with severe overjets or limited ability to posture the mandible forward.[3]

This article describes two cases of class II malocclusion treated successfully with twin-block.

CASE 1

An 11-year-old boy in the late mixed dentition period with an Angle's class II division 1 malocclusion reported to the Department of Pedodontics, Kothiwal Dental College, Moradabad, with the chief complaint of protruding maxillary teeth and unesthetic appearance (Figures 1 and 2). On examination, it was found that the patient had developing Angle's class II malocclusion. The mandible was retrognathic and an overjet of 13 mm was recorded. The maxillary anterior dentition was proclined. The overbite was deep and complete. The buccal segments showed a full unit distal occlusion. A construction wax bite with 6 mm mandibular protrusion and 2 mm interincisal separation was recorded. A twin-block appliance was fabricated. Therapeutic trimming of the posterior bite blocks was done to facilitate the eruption of mandibular molars during follow-up visits. After 5 months, reactivation of the appliance was done with mandibular advancement of 3 mm.

Reactivation of the appliance in a sagittal direction is often required during treatment. Patients may not tolerate the

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Progress in Orthodontics

RESEARCH

Open Access

Changes in lips, cheeks and tongue pressures after upper incisor protrusion in Class II division 2 malocclusion: a prospective study

Irmak Partal and Muge Aksu*

Abstract

Background: The etiology of Class II division 2 (CII/2) malocclusion focuses on heredity; however lip, cheek, and tongue pressures that are associated with the environmental effect are considered to have an effect. The aim of this study was to evaluate the relation between perioral pressures and the upper incisor inclination in CII/2 malocclusion.

Methods: Twenty patients (8 females, 12 males; mean age 10.29 ± 0.90 years) with CII/2 malocclusion were included in the study group, and 15 patients (5 females, 10 males; mean age 10.56 ± 1.06 years) with Class I malocclusion were included. The upper incisors were protruded with a utility arch (0.016 × 0.022 in. blue elgiloy wire). Perioral pressure assessment was made with the Iowa Oral Pressure Instrument. Upper lip pressure, lower lip pressure, vertical lip pressure, left-right buccal pressures, swallowing, and maximum tongue pressures were measured. Repeated measure ANOVA was used to test the intragroup differences. Intergroup comparisons were made using two-way repeated measure ANOVA with Bonferroni correction. Relationships between the variables were analyzed using rank correlation (Spearman's rho). The significance for all statistical tests was predetermined at $p < 0.05$.

Results: A significant change occurred in the upper lip pressure, lower lip pressure, and vertical lip pressure; however, significant difference was not found between the groups. Upper lip pressure increased significantly in both groups. In the CII/2 group, lower lip pressure increased after protrusion and decreased after retention, while vertical lip pressure decreased and then increased significantly. Left buccal pressure changes between the groups were not parallel. Right buccal pressure, swallowing, and maximum tongue pressure changes were not statistically significant. Statistically significant correlation was found between U1-NA (mm) and vertical lip pressure (r −0.467).

Conclusions: In the CII/2 group, upper lip pressure increased only in retention. Lower lip pressure increased and vertical lip pressure decreased after protrusion. Nevertheless, these changes did not remain stable after the retention period. The difference between groups was not statistically significant at the end of retention.

Keywords: Class II division 2 malocclusion, Perioral pressure, Incisor position

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ANALYSIS OF CLINICAL EFFICACY OF INTERCEPTIVE TREATMENT OF CLASS II DIVISION 2 MALOCCLUSION IN A PAIR OF TWINS THROUGH THE USE OF TWO MODIFIED REMOVABLE APPLIANCES

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SUMMARY

Analysis of clinical efficacy of interceptive treatment of Class II division 2 malocclusion in a pair of twins through the use of two modified removable appliances.

The interceptive therapeutic approach of a functional type is indicated for the treatment of Class II Division 2 mandibular retrusion with deep bite, where improvement is required not only in occlusal relationships but also in skeletal and aesthetic parameters.

Purpose. The aim of this study is to assess, in two identical twins suffering from the same malocclusion, the effectiveness and clinical stability of functional interceptive Class II division 2 treatment during puberty by mandibular retro-positioning associated with deep bite, and to compare skeletal changes and dental and dental-alveolar changes induced by the application of two different modified removable appliances: Clark's Twin block and Bergersen's Occlus-o-guide.

Results. The results show that both devices allowed for circumvention of the pre-functional therapy phase aimed at correcting the upper labial segment, and for the conversion of the Class II division 1 incisor relationship, they were able to promote significant and obvious clinical effects.

Conclusions. The study shows that Class II Division 2 functional type interceptive treatment of mandibular retrusion with deep bite conducted in the puberal phase through clinical use of modified Bergersen's Occlus-o-guide® allowed for simultaneous resolution of the skeletal, dental-alveolar and dental problems in one step, while that using modified Clark's Twin-block still requires a second phase of treatment necessary to resolve the alignment, levelling, inter-cuspidation of the arches, optimization of the dental overjet and overbite parameters and to the stabilization of the basal Class I.

Key words: occlus-o guide®, Twin Block, Class II division 2, paediatric patient.

RIASSUNTO

Analisi dell'efficacia clinica del trattamento intercettivo della malocclusione di Classe II divisione 2 in una coppia di gemelli omozigoti attraverso l'utilizzo di due dispositivi rimovibili modificati.

L'approccio terapeutico intercettivo di tipo funzionale trova indicazione nel trattamento della Classe II divisione 2 da retrusione mandibolare con morso profondo in cui è richiesto il miglioramento non solo dei rapporti occlusali ma anche dei parametri scheletrici ed estetici.

Scopo. Scopo del presente studio è quello di valutare, in due gemelli omozigoti affetti dal medesimo quadro malocclusivo, l'efficacia e la stabilità clinica del trattamento intercettivo funzionale della II Classe divisione 2 da retro-posizionamento mandibolare associata a morso profondo in età puberale e comparare i cambiamenti scheletrici e le modificazioni dentali e dento-alveolari indotte dall'applicazione di due differenti dispositivi rimovibili modificati: il Twin block di Clark e l'Occlus-o-guide di Bergesen.

Risultati. I risultati ottenuti dimostrano che entrambi i dispositivi hanno consentito di eludere la fase pre-funzionale di terapia volta alla correzione del segmento labiale superiore e alla conversione del rapporto incisale in Classe II divisione 1e sono stati in grado di promuovere rilevanti ed evidenti effetti clinici.

Conclusioni. Lo studio dimostra che il trattamento intercettivo di tipo funzionale della Classe II divisione 2 da retrusione mandibolare con morso profondo condotto in fase puberale attraverso l'utilizzo clinico dell'Occlus-o-guide® di Bergesen modificato, consente di risolvere simultaneamente le problematiche scheletriche, dentali e dentoalveolari in un'unica fase di terapia, mentre quello eseguito tramite l'utilizzo del Twin-block di Clark modificato richiede comunque una seconda fase di trattamento necessaria alla risoluzione dell'allineamento, livellamento, intercuspidazione delle arcate, ottimizzazione dei parametri dentali di overjet e overbite e alla stabilizzazione della I Classe basale.

Parole chiave: occlus-o guide®, Twin Block, Classe II divisione 2, paziente pediatrico.

CLINICIANS' CORNER

Fabrication of the acrylic splint Herbst appliance

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This article describes the fabrication of one type of Herbst appliance, a removable or fixed functional appliance that causes the posturing of the mandible in a forward position. The type of Herbst appliance described in this article consists of a wire framework to which are attached the various parts of the Herbst bite-jumping mechanism. The acrylic part of the appliance is fabricated from splint Biocryl or from methylmethacrylate. The steps of the fabrication of the appliance are described in detail. (AM J ORTHOD DENTOFAC ORTHOP 1988;94:10-8.)

The purpose of this article is to describe in detail one variation in Herbst appliance design.[1-3] This variation incorporates the use of removable or bonded acrylic splints[4-6] that anchor the Herbst bite-jumping mechanism (Fig. 1) to the wire framework. The clinical management of the appliance is described in detail elsewhere in the literature.[7,8]

FRAMEWORK FABRICATION

The acrylic splint Herbst appliance is fabricated on upper and lower work models, usually poured in stone from maxillary and mandibular alginate impressions. A construction bite also is provided, which postures the mandible approximately 2 to 3 mm in an anterior direction and opens the bite approximately 3 mm incisally. The work models are trimmed with the construction bite in place so that the posterior surfaces of the model are trimmed flush with one another.

At the laboratory the models are checked for proper trimming and any excess plaster is removed. The gingival surfaces are cleaned with a laboratory knife (Fig. 2, *A*) and any voids on the work models are filled with plaster (Fig. 2, *B*).

WIRE FRAMEWORK

Maxillary wire framework

A length of 0.045-inch Elgiloy wire is bent to fit the maxillary work model (Fig. 3, *A*). The palatal arch is formed by placing an omega loop in the center of the dental arch between the second premolar and the first permanent molar (Fig. 3, *B*). A lateral bend is then made at the gingival margin of the upper first premolar, bringing it through the interproximal space. The wire is contoured posteriorly along the buccal surface of the canines and first premolars. The wire then is curved through the interproximal space distal to the first molar and brought anteriorly along the lingual surface of that tooth. The wire is kept approximately 1 mm away from the tooth surfaces just above the gingival margin. A similar configuration is used on the opposite side (Fig. 3, *C*).

Mandibular wire framework

The framework for the lower splint is formed on the mandibular work model by means of 0.040-inch Elgiloy wire that is contoured along the lingual surface of the six lower anterior teeth (Fig. 4, *A* and *B*). The wire then passes through the interproximal surface distal to the canine (Fig. 4, *B* and *C*) and passes distally along the buccal surfaces of the teeth. It then curves around the distal surface of the first molar and follows the lingual contour of the posterior dental segment (Fig. 4, *D*).

Articulation of the work models

After the entire wire framework has been completed, it is removed from the work models. Grooves are cut into the base of the work models and the models are placed in the construction bite (Fig. 5, *A*). A small portion of stone is then placed in the lower half of the fixator model holder and the models that are still related by the construction bite are placed on the stone. A small portion of plaster is added to the upper model and the upper member of the fixator is lowered into place. The upper screw of the fixator model holder is tightened and the models are secured further with more stone (Fig. 5, *A*). Before the fixator is opened, the lower screw is adjusted to maintain the vertical height once the wax bite is removed. The fixator is then taken apart.

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ORIGINAL ARTICLE

Occlusal stability of adult Class II Division 1 treatment with the Herbst appliance

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Introduction: During recent years, some articles have been published on Herbst appliance treatment in adult patients, an approach that has been shown to be most effective in Class II treatment in both early and late adulthood. However, no results on stability have yet been published. Our objective was to analyze the short-term occlusal stability of Herbst therapy in adults with Class II Division 1 malocclusions. **Methods:** The subjects comprised 26 adults with Class II Division 1 malocclusions exhibiting a Class II molar relationship ≥0.5 cusp bilaterally or ≥1.0 cusp unilaterally and an overjet of ≥4.0 mm. The average treatment time was 8.8 months (Herbst phase) plus 14.7 months (subsequent multi-bracket phase). Study casts from before and after treatment and after an average retention period of 32 months were analyzed. **Results:** After retention, molar relationships were stable in 77.6% and canine relationships in 71.2% of the teeth. True relapses were found in 8.2% (molar relationships) and 1.9% (canine relationships) of the teeth. Overjet was stable in 92.3% and overbite in 96.0% of the patients; true relapse did not occur. **Conclusions:** Herbst treatment showed good occlusal stability 2.5 years after treatment in adults with Class II Division 1 malocclusions. (Am J Orthod Dentofacial Orthop 2010;138:146-51)

Class II malocclusions in adults are usually treated by either orthognathic surgery or camouflage treatment, depending on the severity of the skeletal discrepancy. However, recently, some articles have been published on Herbst appliance treatment in adult patients. This method has been shown to be most effective in Class II treatment in both early and late adulthood.[1-8]

A prospective cephalometric study by Ruf and Pancherz[1] demonstrated a favorable effect of Herbst treatment on all mandibular parameters, and also the hard- and soft-tissue profile convexities were reduced. Furthermore, magnetic resonance imaging studies have proven that adult Herbst treatment stimulates condylar growth as well as modeling of the glenoid fossa similarly as in adolescents.[4,5] These findings are also supported by histologic data collected from adult rhesus monkeys[9] and rats,[10,11] confirming that even the adult temporomandibular joint can adapt to mandibular protrusion.

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Comparing the effects of adult Herbst treatment and mandibular sagittal split osteotomy on Class II molar and overjet correction, it was shown that more dental changes occurred in the Herbst patients.[12] Therefore, adult Herbst treatment has been recommended for adult Class II Division 1 surgical borderline treatment.[6,7,12] This recommendation agrees with that of Cassidy et al,[13] who concluded that orthodontic treatment would be a better choice for the borderline Class II adults, whereas surgery would be appropriate for more severely affected patients.

Looking at long-term stability of adult Class II treatment, Mihalik et al[14] compared the outcomes of orthodontic camouflage treatment with orthognathic surgery and found that overbite was equally stable in both groups, but overjet relapsed twice as often in surgery patients. Furthermore, the camouflage patients reported fewer functional and temporomandibular joint problems than did the surgery patients, and had similar reports of overall satisfaction with treatment.

Concerning adult Herbst treatment, no results on the stability have yet been published. Therefore, it was our aim in this retrospective study to analyze the short-term occlusal stability of Herbst treatment in young adult Class II Division 1 patients during the retention period.

MATERIAL AND METHODS

The records of all 350 Class II Division 1 patients who were treated with a Herbst appliance at the orthodontic department at the University of Giessen in

ORIGINAL ARTICLE

AJO-DO

Thirty-two-year follow-up study of Herbst therapy: A biometric dental cast analysis

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Introduction: The aim of this study was to analyze the very long-term effects of Herbst treatment on tooth position and occlusion. **Subjects:** Fourteen patients from a sample of 22 with Class II Division 1 malocclusions consecutively treated with the banded Herbst appliance were reexamined 32 years after therapy. **Methods:** Dental casts were analyzed from before (T1) and after (T2) treatment, and at 6 years (T3) and 32 years (T4) after treatment. **Results:** Minor changes in maxillary and mandibular dental arch perimeters and arch widths were seen during treatment (T1-T2) and posttreatment (T2-T4). Mandibular incisor irregularity remained, on average, unchanged from T1 to T2 but increased continuously during the 32-year follow-up period (T2-T4). Class II molar and canine relationships were normalized in most patients from T1 to T2. During the early posttreatment period (T2-T3), there was a minor relapse; during the late posttreatment period (T3-T4), molar and canine relationships remained, on average, unchanged. Overjet and overbite were reduced to normal values in all subjects during treatment (T1-T2). After treatment (T2-T4), overjet remained, on average, unchanged, but overbite increased insignificantly. **Conclusions:** Thirty-two years after Herbst therapy, overall, acceptable long-term results were seen. Stability was found in 64% of the patients for sagittal molar relationships, in 14% for sagittal canine relationships, in 86% for overjet, and in 86% for overbite. A Class II relapse seemed to be caused by an unstable interdigitation of the occluding teeth, a persisting oral habit, or an insufficient retention regimen after treatment. Most posttreatment changes occurred during the first 6 years after treatment. After the age of 20 years, only minor changes were noted. Long-term posttreatment changes in maxillary and mandibular dental arch perimeters and widths as well as in mandibular incisor irregularity seemed to be independent of treatment and a result of physiologic dentoskeletal changes throughout adulthood. (Am J Orthod Dentofacial Orthop 2014;145:15-27)

The great potential of the Herbst appliance in the clinical management of Class II malocclusions has been documented in several investigations and summarized in the textbook of Pancherz and Ruf.[1] Corrections of the Class II dental arch relationship and overjet are mainly accomplished by anterior advancement of the mandible (stimulation of condylar growth), distal movement of the maxillary lateral teeth, and proclination of the mandibular incisors.[2] Overbite reduction results from extrusion of the mandibular molars and intrusion of the mandibular incisors.[3] The Herbst appliance cannot relieve mandibular crowding. Thus, in crowded Class II malocclusion cases, extractions of teeth (mostly the 4 premolars) must often be performed; after that, the Class II problem has been solved with the Herbst appliance. In previous articles on changes after Herbst therapy, the follow-up periods varied between 1 and 10 years, and they usually end in late adolescence or early adulthood,[4-16] when growth-related dentoskeletal changes still can occur.[17,18]

To date, there has been no long-term follow-up study after Herbst therapy in adolescent patients in which the follow-up period ends in the patients' middle life, when growth-related changes in tooth position and occlusion must be considered to be at a minimum or at an end.

Therefore, the aim of this very long-term follow-up investigation after Herbst treatment was to reexamine previous adolescent patients (age, 12-14 years) at least 30 years after treatment. The study was planned to comprise 3 parts: (1) a biometric analysis of dental casts,

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OXFORD

Systematic review

A comparison of the efficacy of fixed versus removable functional appliances in children with Class II malocclusion: A systematic review

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Summary

Objectives: To systematically compare the efficacy of fixed and removable functional appliances in Class II malocclusion in terms of morphological and patient-centred outcomes.
Search methods: A comprehensive search of electronic databases without language or time restrictions was undertaken, applying a pre-specified search strategy. Supplementary electronic searching of orthodontics journals and references list of included studies was performed.
Selection criteria: Randomized (RCTs) and controlled (CCTs) clinical trials involving children under 16 years with Class II malocclusion and overjet more than 5 mm were included.
Data collection and analysis: A range of clinician- and patient-centred outcomes were evaluated and compared. Risk of bias assessment was carried out using the Cochrane Collaboration tool.
Results: Only four clinical trials were found to meet our criteria, of which two were RCTs, comparing the Herbst and the Twin Block appliances. Two further CCTs, compared the Activator to the Forsus and the Twin Force Bite Corrector, respectively. One study was assessed to be at unclear and the remaining at high risk of bias, precluding meta-analysis. There was also significant clinical heterogeneity in terms of methodology, type of intervention and the measured outcomes. Both modalities were effective in correcting the overjet with little differences found in cephalometric changes and a shortage of data concerning patient-centred outcomes.
Conclusion: There is little evidence concerning the relative effectiveness of fixed and functional appliances or in relation to patient experiences and perceptions of these treatment modalities. Further well-designed clinical trials assessing the relative merits of both clinician- and patient-centred outcomes are needed.

Introduction

Functional appliances have been used for over a century in the management of Class II malocclusion being proven to produce a combination of dental and skeletal effects during the treatment phase to effectively reduce overjet in growing patients (1). There are marked differences in the specific choice of functional appliance type internationally with, for example, the Herbst most popular among USA and mainland European orthodontists (2) and the Twin Block (TB) most prevalent in the UK (3).

The primary difference between fixed, removable and hybrid functional appliances is the premium on compliance with removable and hybrid variants whilst full-time wear is guaranteed with the fixed type. Fixed functional appliances may be further sub-classified as fixed rigid, fixed flexible and fixed hybrid (4) The fixed rigid variants including the Herbst appliance have been shown to have both skeletal and dentoalveolar effects (5). Other appliances in this group include the fixed twin block and mandibular anterior repositioning appliance (MARA). Among the fixed flexible group is the Jasper Jumper. Fixed hybrid functionals encompass features of rigid and flexible appliances with a spring

SYSTEMATIC REVIEW

AJO-DO

Complications, impacts, and success rates of different approaches to treatment of Class II malocclusion in adolescents: A systematic review and meta-analysis

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Introduction: We aimed to explore the prevalence and nature of complications associated with Class II correctors in adolescents and their impact on the quality of life (QOL), completion of treatment, and success rate. **Methods:** The review was registered in PROSPERO, and a comprehensive electronic search was performed without language or date restrictions. Randomized and nonrandomized trials, prospective cohort and cross-sectional studies, case series, and qualitative research were included. The Cochrane Collaboration's risk of bias tool and the Newcastle-Ottawa scale were used to assess the quality of included studies. Data were grouped according to appliances design: removable functional, fixed functional, hybrid functional, headgear, and fixed maxillary molar distalization appliances. **Results:** Data from 27 studies were included, of which 11 were deemed eligible for meta-analysis. Overall, 1676 adolescents were included related to fixed functional (n = 682), removable functional (n = 682), hybrid functional (n = 84), headgear (n = 186), and Carriere (n = 42) appliances. The mean number of emergencies was 0.8 (95% confidence interval [CI], 1.1-2.1) and 2 (95% CI, 0.9-3.0) for removable and fixed designs, respectively. However, the rate of discontinuation was 35% (95% CI, 0.28-0.42) and just 1% (95% CI, 0.01-0.1) for removable and fixed designs, respectively. Other QOL dimensions such as eating, sleep, speech, and emotional domains were significantly impaired during treatment with removable functional appliances. **Conclusions:** Removable Class II correctors were associated with a high rate of treatment discontinuation, most likely because of the negative impact on QOL and lack of compliance. More complications were observed with fixed designs, although this did not impact the overall success rates. Further prospective studies are needed to explore patient perceptions and cost-effectiveness to inform treatment decisions better. (Am J Orthod Dentofacial Orthop 2020;158:477-94)

Class II malocclusion has a prevalence of approximately 25% among 12-year-olds in the United Kingdom.[1] Affected children are more likely to experience teasing, with resultant psychological harms and distress[2] and negative connotations for self-esteem and the quality of life (QOL) for both child and family.[3,4]

Currently, Class II malocclusion in growing adolescents can be treated using a wide variety of appliances and techniques, including Class II correction appliances and/or fixed multibracket appliance with a combination of selective extraction and/or the use of interarch elastics. Removable, fixed, intramaxillary, and intermaxillary Class II correctors exist. Intramaxillary appliances are routinely fitted to the maxillary first molars aiming to either restrain the forward growth of the maxilla (eg, removable headgear) or to distalize the maxillary molars using fixed devices (eg, pendulum, Carriere, and distal jet). Functional appliances have an intermaxillary design and can be grouped into (1) removable (eg, Twin-block [TB], activator, and prefabricated appliance), (2) hybrid (eg, Dynamax), and (3) fixed. However, the fixed design can be further subclassified into (1) fixed rigid (eg, Herbst, fixed TB, and mandibular protraction appliance), and (2) fixed flexible designs (eg, Forsus fatigue resistance device). The primary difference between fixed

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SCIENTIFIC SECTION

Check for updates

How accurate are TheraMon® microsensors at measuring intraoral wear-time? Recorded vs. actual wear times in five volunteers

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ABSTRACT

Background: The TheraMon® microsensor is the most recent device developed to measure the wear-time of removable appliances. The accuracy has not been validated intraorally.
Objectives: To determine 1) if the TheraMon® microsensor accurately records time when fixed intraorally, and 2) the effect of the intraoral location on the recorded time.
Methods: A prospective pilot study, using a convenience sample, was carried out in a UK hospital orthodontic department. Five non-patient volunteers wore microsensors positioned palatal to an upper molar, and buccal to a lower molar for 7 days. Differences between actual amount of wear and the wear recorded by each device were calculated. Differences between sites were also examined.
Results: The mean daily wear-time recorded by the upper and lower microsensors combined was 23 hours (95% CI 22.6–23.4), which is a mean under-recording of 4% (CI 2.5–5.8%). The maximum daily under-reporting of wear times was 5.5 hours. Microsensors in the lower buccal sulcus recorded wear-times that were closer to actual wear-times.
Conclusions: Assumptions made by the TheraMon® microsensors software lead to under-reporting of intraoral wear-time, particularly when placed palatally. These discrepancies could be significant in both clinical practice and research. Adjustment of the microsensor software parameters would improve accuracy, irrespective of the intraoral location.

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KEYWORDS
Microsensor; removable appliance; wear-time

Introduction

There have been a number of attempts to develop accurate and reliable devices for measuring the time that patients wear their orthodontic appliances, including headgear (Northcutt 1975; Swetlik 1978; Clemmer and Hayes 1979; Cureton et al. 1991; Güray and Orhan 1997; Lyons and Ramsay 2000; Cole 2002; Lyons and Ramsay 2002; Brandão et al. 2006; Bos et al. 2007) and other removable appliances (Sahm et al. 1990; Ackerman et al. 2009). The latest device, designed to objectively measure adherence to appliance wear instructions is the TheraMon® microsensor (Handelsagentur Gschladt, Hargelsberg, Austria or Forestadent, Pforzheim, Germany), which has been placed in various removable appliances (Kawala et al. 2013; Pauls et al. 2013; Schott, Schlipf et al. 2013; Schott and Ludwig 2014; Tsomos et al. 2014). The microsensor records the temperature every 15 minutes. At each visit the orthodontist can download the data from the microsensor and use dedicated software to interpret the results by making certain assumptions on wear-time. The software currently 'validates' wear-time as those temperature values which fall between 33.5 and 39°C.

It has been reported that the microsensor accurately records the temperature within a waterbath (Schott and Göz 2010; Schott et al. 2011) and in the mouth (Schott and Göz 2011; Pauls et al. 2013), although the methodology of the *in vivo* investigations is unclear. A recent cohort study using the TheraMon® microsensor to 'objectively assess the compliance of patients who wore various types of removable orthodontic appliances in the medium/long term' defined 28–38°C as indicative of wear-time, as they felt that this represented the majority of intraoral temperatures in normal conditions (Tsomos et al. 2014). Additionally, the microsensor was placed posteriorly (buccally or palatally) because the authors reported that there was less variation in intraoral temperature at these locations. To our knowledge, this is the only study using TheraMon® which has considered the stability of intraoral temperature in the methodology. The conclusions from this study relating to intraoral

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Original Article

Patient compliance and orthodontic treatment efficacy of Planas functional appliances with TheraMon microsensors

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ABSTRACT

Objectives: To assess patient compliance and treatment efficacy of preventive expansion treatment with removable Planas functional appliances using an integrated microsensor.

Materials and Methods: Wear time (WT) and behavior of 69 patients undergoing treatment with Planas functional appliances were assessed and analysed using TheraMon microsensors (Gschladt, Hargelsberg, Austria). Patients were followed up for a period of 9 months, and visits were made every 3 months to download WT data from the microsensor and to assess wearing behavior. From individual WT graphs,10 parameters were derived to characterize compliance for each patient. Treatment efficacy was measured by eight parameters determining the level of expansion after 9 months of treatment.

Results: Patients wore their device on average 15.8 $\pm$ 5.2 h/d. WT was unrelated to age and gender, but it was positively influenced by patient habits when keeping appliances during eating, sports, care and handling. Treatment efficacy in terms of intercanine and intermolar expansion was 4.4 $\pm$ 1.9 mm and 4.6 $\pm$ 2.0 mm for the maxilla, and 5.3 $\pm$ 2.0 mm and 4.7 $\pm$ 2.3 mm for the mandible, respectively. Efficacy was negatively affected by poor compliance (WT $<$ 9 h/d) and by high variability of within-subject WT recordings.

Conclusions: Perfect compliance is not necessary to achieve treatment success, but patients should exhibit sufficient wear time to allow maxillary expansion to occur. The TheraMon microsensor offers a new perspective and aid to individualize treatment prescriptions. (*Angle Orthod.* 2019;89:117–122.)

KEY WORDS: Compliance; Microsensor; Functional appliances

INTRODUCTION

Early orthodontic treatment with removable appliances is intended to prevent dentofacial unbalance in the mixed dentition and to reduce the overall need for later complex orthodontic treatment with fixed appliances. Interceptive treatment is based on the principle that correction should be performed before an abnormality has fully developed.[1–3] This idea was supported by King et al.[4] when they focused on the perception of early treatment benefits. The use of a Planas functional device, based on the overall rehabilitation of the stomatognathic system using neuro-occlusal rehabilitation,[5,6] constitutes an effective way to correct early abnormality, including maxillary and mandibular overcrowding in the mixed dentition.[7]

The success of early orthodontic treatment with removable appliances is highly dependent on patient compliance,[8] defined as the extent to which the patient's behavior matches the practitioner's recommendations.[9] Witt et al.[10] described some factors that determined the patient's compliance, such as regimen,

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