Universidad Europea

GRADUATION PROJECT

Degree in Dentistry

TILTED IMPLANT VS SINUS ELEVATION IN MODERN IMPLANTOLOGY

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ABSTRACT

Introduction: There is a high number of patients that cannot be rehabilitated with conventional straight implants in the posterior maxilla, since the residual bone height (RBH) is often insufficient. Therefore, different methods, the use of intentionally tilted dental implants (ITDIs) and two sinus floor elevation techniques (SFE), the lateral window approach and the transcrestal/osteotome approach, have been developed. It is important to compare the different options.

Objectives: The primary objective was to compare the success rates of the different techniques and the secondary objectives were to find out about the complications, as well as indications and contraindications of the different approaches.

Material and Method: A research question was formulated, and the literature review was conducted through Pubmed/Medline and Google Scholar, by using the keywords and adapted terms. Only English scientific articles, published between 2017 and 2022 were used, limited to studies conducted in humans, presenting a partially or fully edentulous maxilla with insufficient alveolar bone height. **Results**: After the inclusion and exclusion criteria were applied, 43 articles were extracted. Finally, 26 articles were chosen for the review in order to compare the mentioned aspects of ITDIs and SFE techniques.

Conclusions: Both techniques present with very high success rates, slightly augmented for ITDIs. For ITDIs values of 92,4-100% and for the SFE 65,3%-100% were found, with a follow-up 2-11 years and 1-11 years, respectively. Both are described as predictable techniques, whereas the SFE, especially the lateral window approach, brings a higher risk of suffering from intra- and postsurgical complications. The indications are mostly based on the present bone height, the lateral SFE recommended in case of RBH <5mm, the transcrestal SFE with RBH 5-7mm and the ITDIs with RBH >7mm. Contraindications are usually related to general conditions or the RBH.

KEY WORDS

Dentistry; dental implants; tilted implants; sinus lift; posterior maxilla

RESUMEN

Introducción: Muchos pacientes no pueden ser rehabilitados con implantes convencionales en maxilla posterior, ya que muchas veces la altura ósea restante (AOR) es insuficiente. Por eso, se han desarollado diferentes métodos, como los implantes angulados y la elevación del seno maxilar (ESM), el abordaje de la ventana lateral y el transcrestal. Es importante comparar las opciones.

Objetivos: El objetivo principal fue comparar las tasas de éxito de las diferentes técnicas y los objetivos secundarios fueron descubrir las complicaciones, las indicaciones y contraindicaciones de los distintos abordajes.

Material y método: Se formuló una pregunta de investigación y se realizó una revisión de la literatura a través de Pubmed/Medline y Google Scholar, utilizando las palabras clave y términos adaptados. Solo se utilizaron artículos científicos en inglés, publicados a partir de 2017, limitados a estudios realizados en humanos que presentan una maxilla parcialmente o totalmente edéntula con la AOR insuficiente.

Resultados: Después de aplicar los criterios de inclusión y exclusión, se extrajeron 43 artículos. Finalmente, se eligieron 26 artículos para comparar los aspectos mencionados de los implantes angulados y las técnicas de la ESM.

Conclusiones: Ambas técnicas presentan tasas de éxito muy altas, ligeramente más altas con implantes inclincados. Para implantes angulados se encontraron valores del 92,4-100%, y para SFE del 65,3%-100%, con un seguimiento de 2-11 años y 1-11 años, respectivamente. Ambas son descritas como técnicas predecibles, mientras que la ESM, especialmente el abordaje de la ventana lateral, conlleva un mayor riesgo de sufrir complicaciones. Las indicaciones se basan principalmente en la AOR, siendo la ESM lateral recomendada con AOR <5mm, la ESM transcrestal con AOR de 5-7mm y los implantes inclinados con AOR >7mm. Las contraindicaciones suelen estar relacionados con las condiciones generales o la AOR.

PALABRAS CLAVE

Odontología, implantes dentales, implantes angulados, elevación de seno, maxilla posterior

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1. INTRODUCTION

1.1 History of implantology and components of a dental implant

Throughout the last centuries, requirements regarding the importance the oral cavity's function have significantly evolved. In ancient times, the teeth's state formed a need for survival, allowing the people to exert masticatory forces in order to process food. Thanks to the later availability of processed food, it is no longer a necessity for survival, whereas the significance of aesthetics and appearance has increased. Since there have always been issues associated with the loss of teeth, different populations over time have intended various approaches on how to restore the function and aesthetics of the oral cavity by transplanting teeth or implanting tooth-like structures. The treatment of choice in many cases nowadays, in case of partially or complete edentulism, is the implant placement with a prosthetic restoration on top, because of its various advantages compared to conventional bridges. It is a structure simulating the tooth's root and is, in most cases, made from titanium. With a successful implant therapy, by providing great stability and high amount of support, the main mechanical concepts are achieved very well. Together with great retention within the jawbone and the biggest amount of strength among prostheses, implants usually have a very long durability in the patient's mouth. Furthermore, very high aesthetic demands can be satisfied, and advancing resorption of the alveolar bone can be arrested. The first attempt, where similarities with the current implantology concept could be recognized, appeared during the 18th century, consisting of transplanting teeth from one person to another. This procedure was prone to infection which made survival rates not very promising. Only 2 centuries later, the possibility of truly substituting the tooth's root appeared, before, revolutionarily, a basket-shaped endosseous implant was introduced. The word endosseous describes an implant being inserted and fixed into the jaw. 25 years later, the "threaded cylindrical shape with a smooth gingival portion [with] a healing abutment"(1) was introduced into the field of dentistry. This type, when made of cobalt-chrome-molybdenum, was the first one to

present with evidence for a lifelong success in a patient.(1) An endosseous implant nowadays consists of three parts: The first part is the so-called fixture or implant which is directly screwed into the maxilla or the mandible, being responsible for the anchorage within the jawbone. The second part is the abutment, forming the connecting part between the implant itself and the crown, limiting its rotation. Both parts are usually made from titanium. The third part is the prosthetic piece, the crown, which is the visible part in the mouth and can be either fixed or removable.(2) The difference between the implants that were used in the past and the ones of nowadays, since they were introduced by Branemark in 1982, is the osseointegration. At the interface of the currently used endosseous implants and the bone, a connection called “Osseointegration” is formed. Branemark described the concept of osseointegration as “a direct structural and functional connection between ordered, living bone and the surface of a load carrying implant.”(3), whereas before, no intimate connection with the bone, but only ‘Fibrointegration’ could be achieved. The implants of choice today exist in very different shapes and surface “retention schemes”(1), made of zirconia or mostly, the very biocompatible material titanium.(4) Besides the material, the degree of osseointegration depends on the implant’s surface. The roughness can be classified into macro-, micro- and nano-level modifications. The macro-level describes the diameter, the shape, which may be tapered or parallel, and the thread pattern. The use of a wide, tapered implant offers the best distribution of the occlusal forces to the surrounding bone. Threading merely improves the primary stability of an implant by increasing the contact surface with the bone. The micro-level modification can be achieved by either addition or subtraction processing and brings an even bigger contact surface. That way, secondary integration is enhanced by triggering an increased bone activity on a cellular level. A further increase of the surface roughness on the nano-level can be achieved by laser ablation.(4) These surface irregularities are required for good fixation in the bone and cellular adhesion. However, in the very coronal part, where the implant is in contact with the gingiva, a smooth surface showed better results concerning soft tissue integration and health of peri-implant mucosa. Therefore, the hybrid design was

introduced, which combines a smooth surface of the most coronal 3mm with a roughened surface of the rest of the implant.(5)

1.2 Anatomical pre-requisites for implant rehabilitation – quality and quantity of bone

Regardless of what type of implant is used, a healthy gingiva and sufficient quality as well as volume of bone is required in order to consider an implant therapy. Therefore, it is necessary to start with a proper treatment planning, using the CBCT imaging technique for a precise soft and hard tissue evaluation in 3 dimensions and the possibility to include virtual planning(2) as well as the measurement of the mineral content and therefore, the density at the implant site.(6) Regarding the bone state, presurgically, it must be made sure that the width, the length and the depth is present sufficiently. The width describes the available bucco-lingual extension. The length, being the mesiodistal extension, indicates the number of implants that can be placed, and the depth determines the distance between the "crest of the ridge until the nearest limiting (anatomical) landmark".(2) In order for good integration of the implant as well as a healthy gum and papilla appearance to happen, it is necessary that the mesiodistal and the buccolingual extension of the bone is at least 3 mm wider than the chosen implant.(2)

In order to classify the state of the alveolar ridge in terms of quantity,
Cawood and Howell described the following classification in 1988:
(Figure 1)(7)

Stage 1: Pre-extraction

Stage 2: Post-extraction –

the extraction socket still preserves its shape with potential sharp edges.

Stage 3: Well-rounded, high ridge –

bone remodeling has occurred, the extraction socket is filled with bone.

Stage 4: Knife-edged ridge –

the alveolar crest appears in a very sharpened state but the height.

and width are still acceptable.

Stage 5: Well-rounded, low ridge –

further resorption gives back a rounded shape to the ridge, but, due to a significant loss in height and width, the alveolar ridge does not existent anymore.

Stage 6: Depressed bone level – first signs of the resorption reaching the basal bone.

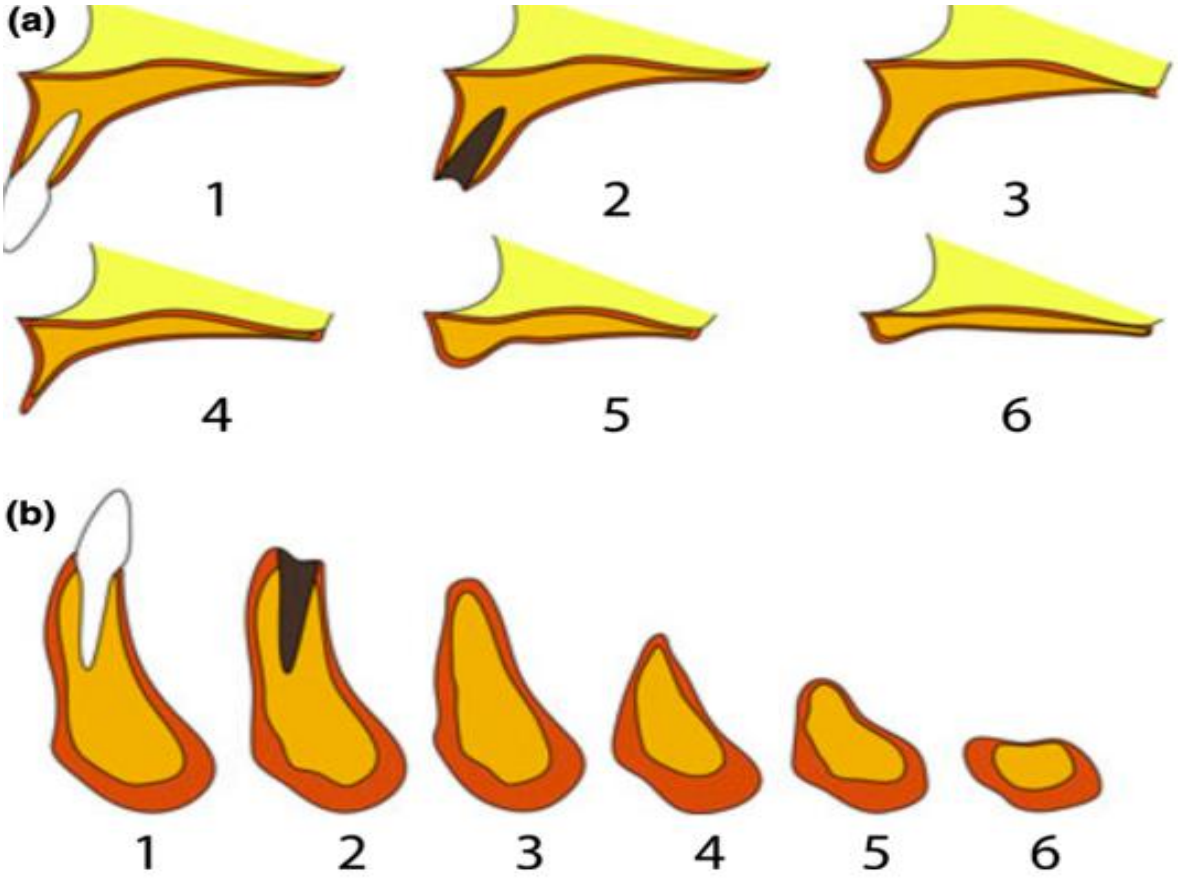

Figure 1. Classification of the six atrophy stages (7).

Besides the quantity of bone, it is just as crucial to evaluate the site-specific bone quality, since it has great impact on the primary stability and therefore its survival.(6) The bone density is measured in Hounsfield units and was classified by Misch, being renamed by Lekholm & Zarb into Type I-IV (Figure 2).

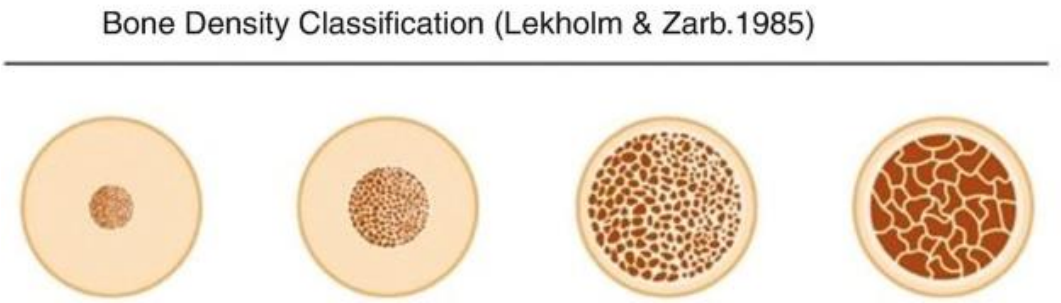

Figure 2. Bone density classification by Mish 1987 and Lekholm & Zarb 1985(8).

Type I indicates the highest density and Type IV the least. All four types of densities can be found in nearly every sector of both jaws with Type II and Type III (found in 74,15% of the implant sites), being the most favorable for implant placement. In order to achieve a good prognosis in the case of Type I, the surgeon eventually needs to adjust the number and size of the implant and the drilling protocol. In the presence of Type IV drilling has to be done cautiously to avoid overheating of the hard bone.(9) It must be considered that in most patients the lower jaw shows a significantly higher density than the upper one. That's because the mandible rather absorbs the masticatory forces, whereas the function of the maxilla is to distribute these forces. More specifically, the bone in the posterior maxilla presents the lowest density. Additionally, age has a negative influence on the mineral content in both sexes. Due to all those aspects influencing the treatment planning, it is essential to evaluate quantity and quality of every case individually. That's why implant selection, drilling protocol as well as the treatment's timing can be adjusted and the best possible outcome achieved.(6) Regarding the state of the periodontium, the presence of sufficient fibrous connective tissue in terms of thickness is essential. Furthermore, enough attached keratinized tissue and a symmetric gingival contour is needed. Generally, the thick gingival biotype is easier to handle and to predict satisfying aesthetic outcomes.(2) In many cases these pre-requisites are not naturally given, which makes pre-prosthetic surgery necessary before the initiation of the implant placement. Especially in the posterior maxillary area, due to the anatomical limitation, the maxillary sinus, in relation with the low

bone density, specific techniques are necessary to make implant placement possible and to increase the probability of a successful outcome.

1.3 Anatomy of the Maxillary sinus

The maxillary sinuses are the biggest paranasal sinuses with a pyramidal shape(10), located within the body of the maxilla and are limited by thin bony walls(11). They are covered by the mucoperiosteal bilaminar “Schneiderian membrane”, consisting of the periosteum facing the bone surface and the ciliated columnar epithelium towards the antrum.(12) Literature presents the following aspects to explain its function. By decreasing the weight of the head and absorbing certain forces exerted on the head, the risk for concussions is lowered. The airspace also plays a role in vocal resonance, supports the immunologic function of the nasal cavity and contributes to the humidification of the inhaled air and the pressure control, for example while masticating. The blood supply of the maxillary sinus is mainly provided by the infraorbital, sphenopalatine, posterior superior alveolar and greater palatine arteries, all being branches of the maxillary artery. Vascular drainage occurs into the maxillary vein in the posterior part and into the facial vein in the anterior part, and finally into the internal jugular vein. The superior alveolar plexus, together with the infraorbital nerves, from the second branch of the trigeminal nerve, innervate the sinus. Their shape and volume undergo major changes throughout the period of development. At birth, its greatest extension is anteroposterior, before it starts increasing its dimension in the lateral and finally the vertical dimension.(11) Its maturation strictly follows the guidance of the permanent teeth and therefore reaches its maximum size at the age of around 20 years(11), after 3rd molar eruption, with a mean volume of 12,5ml, ranging from 5,0 to 22ml.(10) Due to the relationship between the teeth location and the shape of the maxillary sinus, as well as the decrease of the mineral content in the bone matrix and the osteoclastic activity of the Schneiderian membrane with increasing age, the sinus undergoes a process, called ‘Pneumatization’. This describes a decrease in size, and a change of shape throughout life. By extracting the maxillary premolars and molars, the floor of the sinus moves in an apicocoronal direction, especially in the areas where the apices were reaching into the

airspace. Additionally, since the bundle bone is not stimulated by the mechanical mastication forces any more, the alveolar bone undergoes resorption in coronoapical direction. These two processes together, lead to a decreased height of the alveolar crest. In partially edentulous patients, this size reduction is more significant than in completely edentulous and of course in dentate patients.(12) Regarding its anatomical limits, anteriorly, the sinus is limited by the maxilla's facial surface and 2 landmarks stand out on its surface: the infraorbital groove with the infraorbital foramen in the superior region and the canine fossa in the inferior region. Posteriorly, the sinus is separated from the pterygopalatine fossa by the maxilla's infratemporal surface. The lateral wall comprises the zygomatic bone, whereas the medial wall communicates with the nasal cavity by presenting with a 3-6mm elliptical-shaped opening on its smooth surface, called ostium. This allows the drainage of mucous, avoiding further complications like a sinusitis. (Figure 3B) The superior limit is formed by the very thin orbital floor and includes the infraorbital canal. Having a precise knowledge about the curved floor of the maxillary sinus, which extends into the zygomatic process and may reach into the zygomatic bone, has the greatest importance for dental surgeons in case of posterior maxillary rehabilitation treatments. Since the growth of the maxillary sinus is guided by the permanent dentition, it normally extends from distal of the third molar to mesial of the first premolar. The lowest point of its convex, around 2mm thick compact bone towards the oral cavity, is located at the level of the first and second permanent molar. Their radicular tips are in close relationship (40%) with the sinus or, rarely, the apices may even reach into the antrum (2%). The buccodistal root of the second molar is usually the one being the closest to the sinus floor. Another crucial landmark to evaluate precisely with the help of the CBCT imaging technique, previous to an implant therapy affecting the sinus, are the septa. (Figure 3A) They are thin bony walls, present within the sinus in 16-58%, potentially above an edentulous ridge. They may be congenital or acquired, following a tooth extraction. This explains why their prevalence is higher in edentulous patients. (10,11)

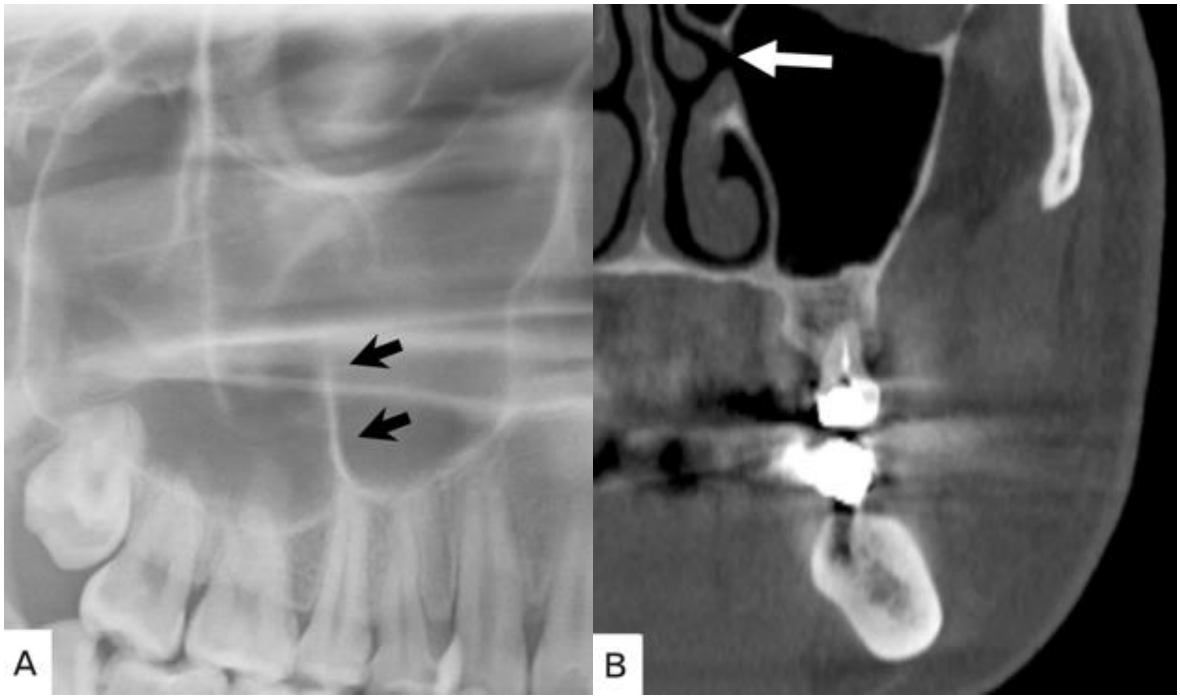

Figure 3. Radiological image of the sinus anatomy (A) Demonstration of the intra-antral septum and the relation of the molars with the floor of the sinus (B) Frontal section of the maxillary sinus related to the nasal cavity, the oral cavity and the floor of the orbit (10).

Due to the previously explained characteristics of the sinus and the high likelihood of resorption of the alveolar bone, an alternative to conventional rehabilitation of the posterior maxilla with axial implants is necessary.(13) Different options have been developed for such cases, like the use of short implants, zygomatic implants, tilted implants or elevating the floor of the maxillary sinus. In this literature review the focus is set on the option of implanting intentionally tilted dental implants and the alternative of augmenting the sinus floor, called 'Sinus floor augmentation', Sinus lift' or 'Sinus floor elevation'.(14)

1.4 Intentionally tilted dental implants (ITDIs)

Even though, it is usually emphasized that the direction of the masticatory forces should be axial to the implant, in case of insufficient alveolar crest height, one alternative is the placement of tilted implants. By tipping the implants, anatomical limitations, such as the maxillary sinus or the inferior alveolar nerve in case of the mandible, can be avoided without the need of a more invasive bone grafting procedure. For the case of a completely

edentulous arch, Paulo Maló introduced the “All-on-four” concept in 2003, which describes the use of two axial implants in the anterior region and two angulated implants in the posterior region, with an angulation of 35-40 degrees. A modification to that system is the “All-on six concept”, where instead of one, two implants are placed in the anterior area (Figure 4).

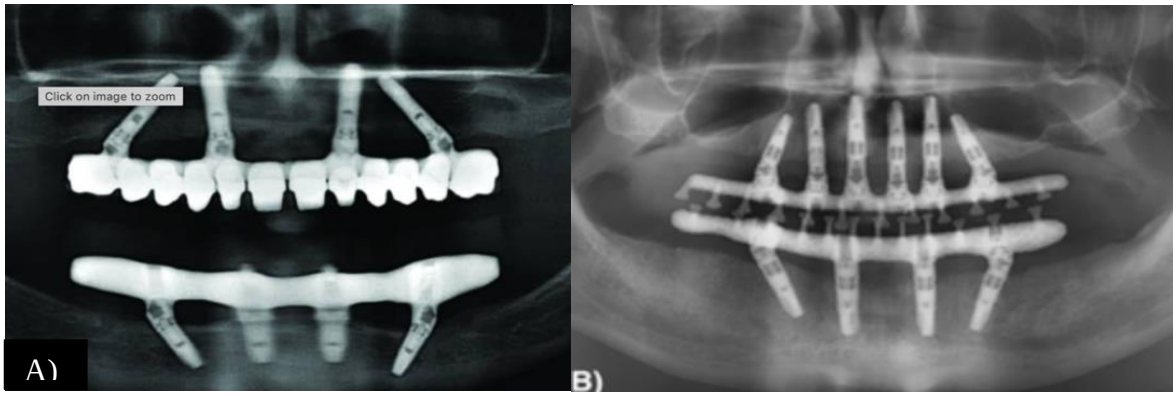

Figure 4. (A) „All-on-four “-concept with 2 axial anterior implants and 2 tilted posterior implants in the premolar area (15), (B) “All-on-six”-concept with 4 axial anterior implants and 2 tilted posterior implants in the molar area (Panoramic radiographs)(16).

The first step of the placement appointment, after a transcrestal incision and full-thickness flap reflection, is the osteotomy sequence of the implant system used, in the tilted direction, so that anatomical limitations can be avoided. Following, angulated abutments screws are placed on top to be able to place an aligned prosthesis in the next step.(17) Finally, the surgical site is closed by suturing, if needed. That way the need for bone grafting is eliminated together with the avoidance of invading anatomical limitations. For the treatment planning it is important to know that, the higher the angulation in between implant and crown, the the stress levels on the implant-bone interface.(18,19)

1.5 Sinus floor elevation techniques (SFE)

The sinus elevation technique allows to surgically increase the alveolar bone height in the area of the edentulous space and can be done in two ways. The options are the ‘Lateral window/direct approach’ or the ‘Osteotome transcrestal/indirect approach’.(20) The first

technique to be used was the lateral window approach, introduced by Oscar Hilt Tatum Jr during the 70s. It is initiated by an incision in the buccal sulcus(13) and a full-thickness flap is raised. Then, a window is drilled into the thin, lateral wall of the sinus using either piezoelectric instruments or a high-speed handpiece until a bluish-purple color, indicating the Schneiderian membrane, is seen. The window is supposed to be located 2-3 mm above the inferior limit of the sinus and reaches until the distal aspect of one of the molars. A curette is used to lift the lining membrane and bone grafting material can be inserted or not into the created space. Finally, a collagen membrane may be positioned over the opening and the flap is sutured back. (Figure 5)(13)

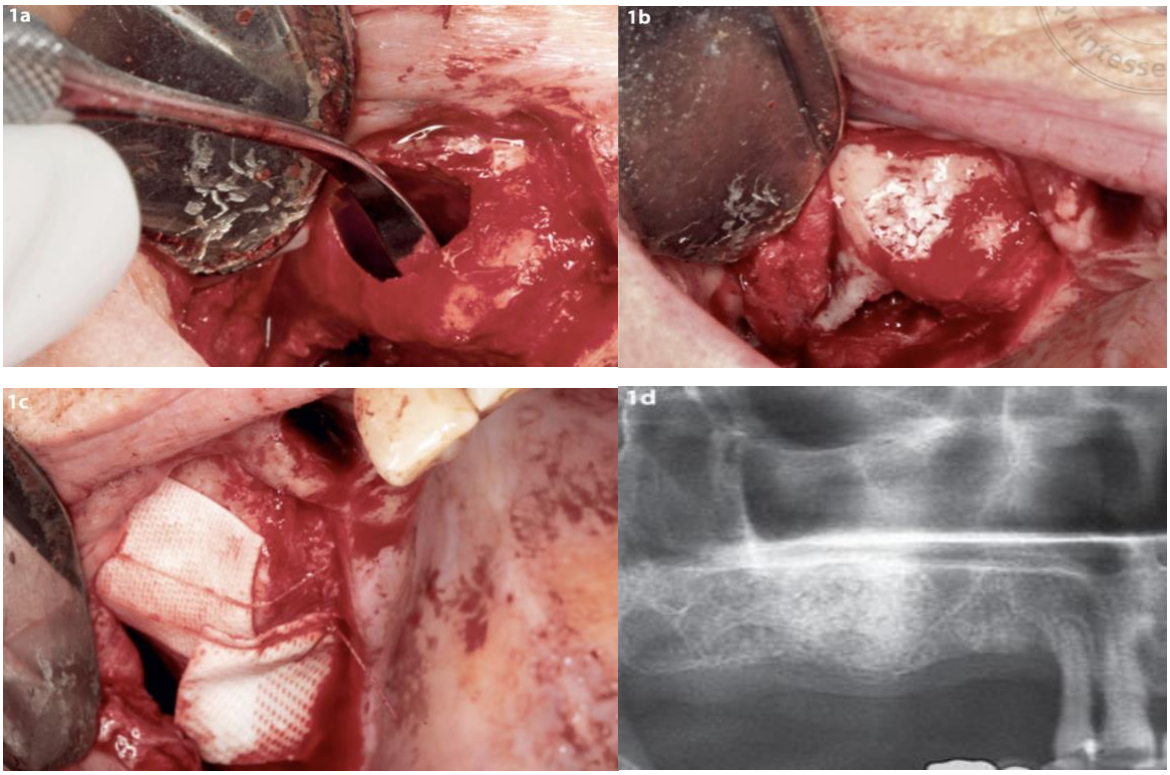

Figure 5. Lateral window approach for sinus augmentation: (a) open lateral window and elevation of Schneiderian membrane (b) placement of bone graft below the membrane (c) coverage of open window with collagen membrane (d) Postoperative radiograph (20).

Around 20 years later, Summers introduced the 'Osteotome transcrestal/indirect approach' with the aim of limiting complications and treatment time. Equally to the previously explained technique, also a full-thickness flap is raised, but at the crestal area, right where

implant placement is being foreseen. After that, a pilot osteotomy, with a lesser extension than of the final implant, is performed. The drilling protocol indicates the use of osteotomes with a gradually increasing diameter for compactation of the bone in the lateral and apical area and in order to achieve the elevation of the membrane. These osteotomes are drills that have an atraumatic tip in order to also avoid breaking the Schneiderian membrane. Then, a bone grafting material can be introduced or not into the drilled space and the flap is sutured back. (Figure 6)(13)

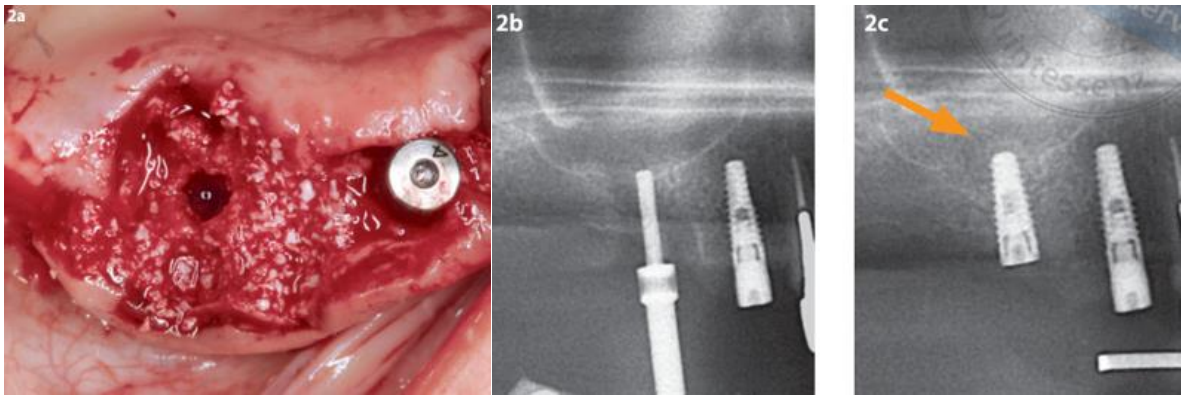

Figure 6. Transcrestal approach for sinus augmentation (a) Osteotomy preparation, simultaneously to the molar extraction (b) Penetration to the sinus with an osteotome (c) Postoperative radiograph of the placed implant with the bone graft above the implant apex (20).

In both cases, the insertion of the required implants can be done simultaneously (One-step-surgery) or after a healing time of around 6 to 9 months. (Two-step-surgery).(20)

Thanks to different techniques that were described during the last centuries, nowadays, implant rehabilitation is possible even in the case of insufficient bone volume for the placement of an axial implant in the posterior maxilla. Among them, the use of tilted implants and a pre-surgical sinus elevation are known to be two promising techniques. For a reasonable decision-making, it is important to know the precise success rate, the most frequent complications and the indications as well as contraindications of each of them.

2.OBJECTIVES

Main objective: Compare the success rate of both techniques, the sinus elevation technique and the placement of tilted implants, in the case of insufficient amount of bone for the placement of conventional implants in the edentulous posterior maxilla.

Secondary objectives:

1. Give answers about the complications that may appear related to the use of either of the two techniques.
2. Explain indications as well as contraindications for the use of tilted implants and the sinus elevation technique.

Principal hypothesis: The use of intentionally tilted dental implants has a similar success rate as the sinus elevation technique.

Secondary hypothesis: Both techniques, sinus elevation and the use of tilted implants, are associated with a broad range of complications.

3.MATERIAL AND METHOD

In order to find answers to the previously stated objectives, the reviewed literature was acquired through an electronic search of Medline/Pubmed and Google scholar with the use of the following keywords: dentistry, dental implants, tilted implants, sinus lift, posterior maxilla. In the systematic search, the synonyms for tilted implants, being angulated implants and tipped implants were included, as well as sinus lift and sinus augmentation for sinus elevation. Only articles published between 2017 and 2022 in English were selected. In a first electronic search, 467 articles were identified. Applying the inclusion and exclusion criteria (Table 1), of those, the title and abstract of 137 were screened. Following, 43 articles were chosen for a full text analysis and assessed for eligibility. 17 articles were excluded due to the impossibility of differentiating the results obtained in the maxilla and mandible

and the content not being a perfect fit for the objectives of this review. Finally, 26 articles were included in the literature review. (Figure 7)

Table 1. Selection criteria

Inclusion criteria	Exclusion criteria
• Articles published within the last 6 years	• Articles published more than 6 years ago
• Studies performed in humans	• Studies performed in animals, in vitro
• Studies with a follow-up duration of minimum 12 months	• Studies performed throughout less than 12 months
• Implant placements that were done immediately or delayed	• Impossibility to differentiate outcome of axial and tilted implants when using the All-on-4/6-concept
• Placement of tilted implants or a performed sinus augmentation before implant placement	• Impossibility to differentiate data of maxillary and mandibular implants
• Implant placements that were done in the partially or fully edentulous upper maxilla	• Meta-analysis, case reports, letters, comments to the editor, expert reports
• Systematic reviews, randomized clinical trials, controlled clinical trials, cohort studies, case series	• Articles in any language except English
• Articles in English were included	• Samples of less than 10 subjects
• Samples of minimum 10 subjects	

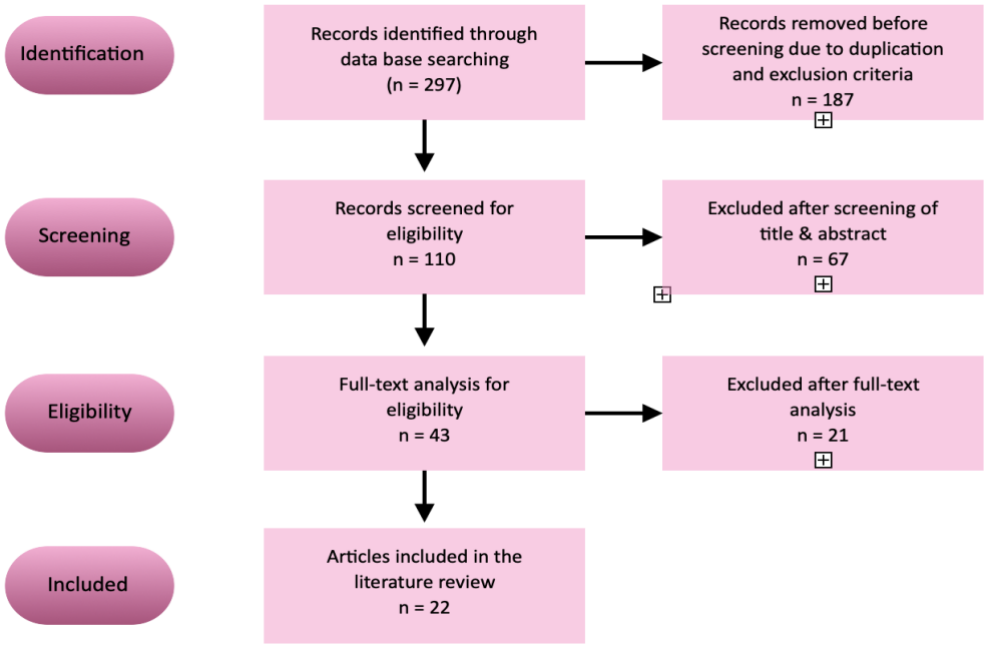

Figure 7. Flow chart of the literature review and the selection procedure.

Research PICO question:

To examine the success rate, possible complications and the indications as well as contraindications for the placement of tilted implants and a sinus elevation before implantation, in patients with an edentulous posterior maxilla of insufficient alveolar bone height, in order to allow the placement of conventional axial implants.

P: Patients with an edentulous posterior maxilla of insufficient bone volume, requiring an implant

I: Tilted, angulated, tipped, tipping implants

C: Sinus elevation, sinus lift, sinus augmentation

O: success rate, survival rate, implant prognosis, implant survival, implant success, biological complications, mechanical complications, complications, indications, contraindications

The search equation was as follows (((((((((dentistry) AND (dental implants) AND (tilted implants) OR (angulated implants)) OR (tipped implants)) AND (sinus lift)) OR (sinus elevation)) OR (sinus augmentation) AND (posterior maxilla)).

4. RESULTS

4.1 Success rates

The reviewed articles that include studies with a follow-up of at least a year, vary slightly in their results. Firstly, the percentages of success rates when utilizing ITDIs, are going to be listed. The long-term retrospective review by Testori et al describes that 48 tilted implants placed in the maxilla, as part of the All-on-six approach, have a survival rate of 93,75% (45/48) for a follow-up of 10 years. Furthermore, the study declares an overall survival rate of 92,4% in case of smokers, compared to 97,4% in nonsmokers. In case of failed implants, the antagonist teeth were always implant-supported prostheses. Most of the failures occurred during the first 2 years post-surgical.(21) The systematic review executed by Gaonkar et al concludes a survival rate of 94,8%-98% during a follow-up period of 72-132 months for the axial and tilted implants with no significant difference between them. The prostheses were successful in 99-100% during a period of 12 months. (22) In their literature review of 18 articles about the All-on four concept, Soto-Penaloza found a minimum success rate of 94,8% after 10 years. Other than that, they state a 95% survival rate in a study conducted with 172 implants followed over 5-10 years and 2 studies with a 100% success.(23) Hopp et al conducted a retrospective clinical study with 1178 maxillary ITDI placed as part of the previously explained All-on-four concept. They found a success rate of 96,1% (1109/1178) of the angulated implants after a follow-up of 5 years. 71% of the implant failures happened within the first year but their prosthetic survival rate was 99,8%. Additionally, they bring up the survival rate value of 95%-100% through a literature review.(24) According to Slutzkey et al, in their 5-year retrospective cohort study, which includes 46 ITDIs, associated with the All-on-four or All-on-six concept and ridge augmentation, this surgical option reveals a survival rate of 97,8% (45/46) and a very satisfactory prosthetic success of 100%. (25) A success rate of 98,5% (67/68) was stated by Menendez-Collar et al. in their 2-year-study of 187 implants, being combined with axial implants to support a complete maxillary FDP. Furthermore, they say that the inclination of the screw related to the occlusal plane, does not affect the success. (29) Szabó et al reaches a 100% survival rate after 3,5 years of distally ITDIs right anterior to the maxillary sinus, even

without excluding patients with underlying pathologies. Additionally, they found that ITDIs are easily accepted by patients in comparison with bone augmentation methods and the angulation of the implant limits the extension of the distal cantilever, leading to very good survival rates.(26) The success rates found in the reviewed articles for SFE are as follows: Barbato et al state that in their retrospective study with a follow-up range of 4-11 years, 77,10% (64/86) of the implants, placed 9-12 months after performing a lateral window SFE, were successful. 41% of the patients were smokers. They concluded that only 2 factors can have an impact on the implant failure or survival, which are smoking more than 15 cigarettes per day and residual bone height below 4mm. They claim that per millimeter less than 4mm of residual bone height, the risk of implant failure rises by 3,8-fold.(27) A significantly greater success was found in the literature review done by Deevamena et Dinesh, in the case of nonsmokers with a value of 82,7% (130/158) after a mean follow-up of 3,5 years, whereas for smokers it was only 65,3% (46/70).(28) The retrospective study of Tartaglia et al with 289 implants placed with the lateral window technique, separated their subjects in two groups that both included the same amount of smokers. They evaluated the implant placement after a sinus floor augmentation with bone grafting and the one without bone grafting and followed them up for 6 years. Survival rates of bone grafted SFEs and elevation with blood clot alone at one year were 94,2% (152/162) and 85,9% (109/127), at 3 years, 91,1% (147/162) and 81,6% (103/127) and at 6 years, 91,1% (147/162) and 78,7% (100/127), respectively. Lower survival rates were found in case of graftless procedure, especially when the residual bone height was between 4-6mm, in periodontally compromised subjects and smokers.(29) Romero-Millan et al conducted a retrospective study of 329 implants with a follow-up of minimum 5 years and found success rates at 1 year of 93,8% in case of simultaneous sinus lift and implant insertion and 98,1% with delayed implant insertion after sinus lift. At 5 years they reached values of 93,8% and 91,5%, respectively. The survival rate after 12 years was only 44%.(30) Qian et al evaluated the survival rate of implant placement combined with an osteotome SFE, with patients randomly assigned to perform the SFE with an insertion of a bone graft and without. The survival rate after 10 years for 10-mm implants was 95,0%. The survival rate of the

prostheses were 100%, only in 17,5% (7/40) of the cases, chipping happened.(31) Pursuant to Bacevic et al, their study gave the result that 100% of the implants inserted after a direct SFE, succeeded for one year.(32) Gherlone et al published the only study that was included in the review, directly comparing the treatment options under investigation, more precisely finding results regarding the success rate in case of direct SFE, indirect SFE and ITDIs with a follow-up of 4 years. They found survival rates of 95,83% (2/48), 95,65% (2/46) and 98% (1/50) for the different groups, respectively. Prosthetically, there were no complications detected during the follow-up period.(33)

4.2 Complications

First, it must be clarified that the complications that may appear with the different implant treatment options can be classified in intraoperative and postoperative on a time level and into surgical/biological and prosthetic on a location level.

4.2.1 Intraoperative complications

Firstly, the importance of a precise previous clinical and radiographical diagnostic about the bone quality, shape and the sinus conformation needs to be underlined. The pathway of its blood vessels need to be projected, in order to be able to preview potential obstacles and not let them turn into complications when performing the surgery.(33,34) According to Gherlone et al, with the use of ITDIs, the risk of being confronted with intraoperative complications is the lowest, since in that study no issues occurred during the surgery. Comparing to that, in case of the direct SFE, in 3 out of 20 patients a membrane perforation occurred throughout the intervention which were fixed intrasurgically.(33) The most common intraoperative complication in case of performing a sinus floor elevation is the rupture of the lining Schneiderian membrane during the attempt of separating it from the bony floor of the antrum. In compliance with Bacevic et al, in case of using the lateral window technique, it happens in 18,3% of the cases. In case of this incidence when grafting the sinus with the transcrestal approach, in order to fix the present perforation, it is necessary to switch to a lateral window approach, but they claim that membrane rupture is not correlated with implant failure.(32) Kim et Jang, in their systematic review, found the

incidence of 10-34%, mentioning that the incidence is higher in smokers because their habit provokes the Schneiderian membrane to be thinner and therefore more fragile. They observed that the success rate of the implant placement depends on the size of the perforation. In case of a rupture smaller than 5mm, the success rate was 97,14%, in case of 5-10 mm, it decreased to 91,89% and when it was bigger than 10 mm, they found a value of only 74,14%. When the protocol was not changed to a two-stage surgery, but the implant was still placed simultaneously, a successful outcome was achieved in 90,81% of the cases.(34) Beck-Broichsitter et al states that a perforation happened in 10-44%. They point out that if the tear can be sutured or covered during the surgery or the protocol can be extended to a two-stage surgery, a perforation does not decrease the outcome.(35) Bacevic et al also say that with an adequate management of such a complication, satisfactory outcomes can be predicted, similar to the procedure without a tear, even if they mention that in the case of very large perforations, continuing the intervention is absolutely contraindicated. Kim et Jang call the provocation of excessive bleeding during the intervention the second most habitual issue. This problematic occurs mostly with the direct SFE technique due to the position of the infraorbital artery and the posterior superior alveolar artery around the lateral wall of the antral cavity. By a precise study of the CBCT in order to predict the run of the artery as well as opening a small window that is localized as far coronal as possible, the risk may be decreased.(34) In the study of Bacevic et al, no major bleeding was observed during the intervention, however they describe the risk due to the anatomical location of the posterior superior alveolar artery.(32) Other, less frequent complications that may arise with either of the techniques, are the damage of the adjacent teeth, a fracture or fenestration of the cortical and an incorrect angulation or placement of the ITDI or the implant inserted following the sinus floor elevation. Rather associated with the SFE, is the potential penetration of the nasal cavity or the antrum, or even the displacement of the screw into the lastly mentioned space. Moreover, the loss of the graft, a harm at the level of the donor site in case of autologous grafts or a partial or even complete partition of the septum may arrive. (28,36)

4.2.2. Postoperative complications

In terms of postoperative complications after placing tilted implants, a broad range of short-term complications may appear in a high percentage of patients, just like in any implant surgery. The most common ones are suborbital and subnasal hematomas during the first days after the treatment. In the study of Hopp et al, executing the All-on-four concept, they appeared in 43,4% of the patients. Other than that, infections during the first weeks or months, or abscesses are ordinary minor postsurgical complications.(24) In case of the use of the sinus lift technique, the most usual acute postoperative effects are pain, edema, hematoma, hemorrhage and occasionally nose bleeding and a temporary headache. Since the lateral window approach is more invasive and requires more tissue provocation, generally, the postsurgical symptoms seem to persist during a longer period of time than after the transcrestal approach.(32,37) Other than that, as specified by Devameena and Dinesh, an infection at the surgical site appears in around 2-5,6% after this type of intervention(28). A sinusitis with or without an oroantral fistula may arise.(34) A certain complication that only, even if very rarely, appears in association with the osteotome approach, after malleating the sinus floor, is the postsurgical benign paroxysmal positional vertigo (BVVP).(34,37) Conforming to Gherlone et al, BVVP usually resolves without any intervention after maximum 4 months.(33) When speaking about the long-term, the complications that appear most commonly for each of the treatment options, within the first two years, are peri-implant mucositis and peri-implantitis. Peri-implant mucositis is characterized by the inflammation of the mucosa around the screw, including bleeding on probing, redness, edema and potentially suppuration without any bone loss. Latter aspect is the one that makes an easy distinction from peri-implantitis possible which shows an evident bone loss radiographically, accompanied by the equal manifestation of inflammation.(23–25,31) Testori et al state that in their study 1,3% of the tilted implants failed due to peri-implantitis.(21) Slutzkey et al observed in their study that peri-implant mucositis was involved in 22,2% and peri-implantitis in 4,4% of the ITDIs.(25) Concerning the SFE, 3 articles were reviewed that give values about the peri-implantitis prevalence. One shows a 7% (27), another one a 2% prevalence on the follow-up of 9months (35) and the

third one a 4,4% prevalence of peri-implantitis after 6-12 months, in which 28% of the patients suffered from at least one implant with peri-implant mucositis after 10 years.(31) Besides, especially, when elevating the sinus, there is a small risk of suffering a chronic infection or sinusitis, or consequently, the development of a maxillary cyst. Very rarely an idiopathic neuralgia, with or without the damage of a nerve or a change in resonance and therefore in speech are possible outcomes.(34) Barbato et al states that smoking does not have an impact on the prevalence of the beforementioned postoperative complications.(27) Another aspect that must be compared is the marginal bone loss (MBL), because in case of excess it can become a complication on the middle- or long-term after the implant placement. The process of marginal bone loss is described as the distance between the marginal bone and the implant shoulder, that decreases over time(25), and happens around nearly every implant. In relation with angulated implants, Slutzkey et al found that the MBL for tilted implants in mesial is 0.07 ± 0.14 mm and in distal is 0.07 ± 0.12 mm. After 5 years, in their study, the MBL is 0.37 ± 0.68 mm and 0.34 ±0.62 in mesial and distal, respectively. According to this study, the position of the implants and the smoking status does not affect the MBL rate.(25) Another study shows the MBL in the maxilla at three different times, after 1,5, 2,5 and 3,5 years, with values of 0.558 ± 0.029, 0.747 ± 0.030 and 0.770 ± 0.029, respectively. Persuant to their outcomes, they point out that distally tilted implants, smoking and underlying conditions provoke more bone loss.(26) In their systematic review, Gaonkar et al found one study that describes MBL of <1,5mm after a follow-up of 12 months and another study concluding a value of 1,5-1,7mm after 12-60 months for axial and tilted implants, with no significant difference between them. In the study of Menendez-Collar et al, ITDIs present an MBL of 0,17 ± 0,90 and 0,97 ± 1,00 with a big variance depending on the age and other underlying factors. In case of compromising aspects, such as being a smoker, a female or suffering from a cardiovascular condition, Hopp et al say that there is a 2.032, 1.925 and 2.42 higher chance of developing an excessive MBL around angulated implants, defined as a value higher than 2,8mm.(24) Three articles were included, analyzing the MBL after SFE. Romero-Millan et al concludes an average bone loss of 1,4mm during a period of 5 years after performing a direct SFE.(30) According to the

study of Qian et al, when using the osteotome SFE, the MBL after a 5 year-follow-up is between 1.50 ± 0.96 mm with bone-grafting and 1.43 ± 0.76 mm without bone grafting.(31) Apart from these biological complications, a big range of prosthetic complications potentially appear in relation with the provisional or definitive prosthesis placed on top of the fixture and abutment. According to the literature review, the big range of mechanical complications when placing ITDIs, consists of the loosening of the abutment screw, the decementation or fracture of the temporary or final bridge, chipping of the felspathic, superficial layer or even a prosthesis fracture. Slutzkey et al observed that in their study, the decementation of the final bridge was the most common issue with a prevalence of 39%, whereas the provisional bridge was loosened in 34,7% of the cases. Latter was claimed by Gaonkar et al as the most common prosthetic outcome that had to be fixed(22). Soto-Penaloza et al states that the detachment of a part of the definitive prosthesis appears in 23,3% of the cases and therefore, the most.(23) The loosening of the abutment screw appeared in 26% of the cases.(25) Testori et al claims that the most frequent prosthetic complication is the chipping of the outer layer of the prosthesis, occurring in 33,3% of the prostheses, whereas a fracture only happened in 4,2% of the cases.(21) As always, when placing an intraoral prosthesis, achieving a complete esthetic and functional satisfaction, may be a complication. The appearance of the artificial teeth, the lip support and phonetic complaints have to be assessed subjectively and objectively to achieve the best possible result.(25) When the treated patient presents with severe bruxism, the risk of mechanical failure as well as the aggression on the opposing arch is aggravated and should be considered in the treatment planning.(22)

4.3 Indications

Gherlone et al states that it is necessary to proceed with a precise diagnosis of the bone state, through a clinical and radiographical examination, including a panoramic radiography and a CBCT, so that the best technique can be chosen (Table 2).(33)

Table 2. Indications for tilted implants and both SFE approaches (33)

Tilted implants	Lateral window / Direct SFE	Osteotome/ Indirect SFE
• Gherlone et al: Residual bone height (RBH) <7mm • Surrounding area with sufficient bone volume for an ITDI • Fully edentulous: Possibility of performing the All-on-four/six-concept by combining a tilted and an axial implant • Contraindication for SFE: sinus pathology, general state of health	• Gherlone et al: RBH <5mm • Devameena et Dinesh: RBH <6mm • 5-9mm of alveolar bone height must be gained • Surrounding area with insufficient bone volume for ITDI • Fully edentulous: Impossibility of performing the All-on-four/six concept by combining a tilted and an axial implant	• Gherlone et al: RBH 5-7mm • Devameena et Dinesh: RBH 6-8mm • 5-9mm of alveolar bone height must be gained • Surrounding area with insufficient bone volume for ITDI • Fully edentulous: Impossibility of performing the All-on-four/six concept by combining a tilted and an axial implant

Additional to the indications shown in the table, there are other aspects to take into account. Pursuant to Menendez-Collar et al, the use of ITDIs comes with surgical and prosthodontic advantages and, since it allows the insertion of longer implants that can be anchored in more than one cortical plate, a superior primary stability is given. Besides, the intra- and postoperative complications are known to be lower, so especially in elderly or compromised people, that are not absolutely contraindicated to be treated with implants, it should be considered a better option, if the bone level allows.(36) Regarding the two SFE techniques, according to Bacevic et al, the transcrestal approach was developed with the goal of decreasing the trauma.(32) Qian et al still indicates the direct approach as more

predictable and states, it covers a broader range of indications, since it is recommended in case of more severe bone loss.(31)

4.4 Contraindications

In order to be able to make a correct treatment planning, it is necessary to have a precise knowledge about the contraindications of dental implant surgery in general, including both techniques, and the specific ones for either of the options. Following Kim et Jang, the general absolute contraindications for any oral implant surgery are uncontrolled systemic diseases classify the patient as ASA3 or ASA4. For example, severe types of cardiovascular diseases or uncontrolled diabetes decrease the chance of an adequate osseointegration and increase the risk for infection.(34) Gomez de-Diego et al mention that in case of a present cancer treated with large radiation doses on the head and the neck (>50 Grey) a high risk of post-surgical osteonecrosis is triggered and therefore a contraindication. Also, the treatment with intravenous bisphosphonates or when they are combined with immunosuppressors, corticosteroids or hormonal therapy, is regarded a complete contraindication(38), just like patients with severe alcoholism because of their coagulation imbalance**.** Serious mental disorders and drug abuse are included as well. Regarding smoking, the different authors give answers to that as a contraindication. Szabó et al claims that in case of heavy smoking should be considered a contraindication.(26) In the publication of Testori et al the habit was called an important risk factor and most implant failures in their study happened in patients who smoked more than 10 cigarettes a day.(21) The article written by Gomez-de Diego found contradictory results in their literature search, between authors who describe smoking as a factor that increases the risk for failure up to 2,6 times and authors who didn't detect a big impact of cigarette smoke.(38) Besides that, the presence of an insufficient oral hygiene proceeding a rehabilitation with implants, or the lack of motivation to keep the oral cavity in a good state should also be fixed before the treatment, since a proper practice of oral care is crucial for a long-term success of an implant, choosing any technique.(26) Furthermore, severe bruxism can be noted, since it leads to excessive occlusal overload and, according to Chitumalla et al, is therefore

indicated as the main cause of dental implants failure, surely depending on the intensity as well as the frequency of the parafunctional habit.(39) Qian et al also point out that in most of the implant failures that occurred in their study, the patients performed severe bruxism.(40) For the same reason, the tendency of occlusal overload, malocclusions should be considered. Also, with a limited mouth opening ability, implant therapy should be delayed, if possible, to avoid the postsurgical complication of a trismus and facilitating the access and visibility to the surgical site.(34) Another relative contraindication are patients suffering from osteoporosis with low doses of oral bisphosphonates as treatment of choice. These cases need a longer and closer follow-up to for early detection of a potential chemical bone necrosis, whose risk is only slightly increased.(38) Besides, the mentioned contraindications that are valid for any implant surgery, specifically for the tilted implant technique, Gherlone et al brings up that in case of a residual bone height of less than 7mm and an insufficient bone volume is present in the surrounding area, where the apex of the implant points, this technique is not indicated.(33) Kim et al raise the statement that an SFE should not be performed with a present soft or hard tissue lesion. Acute dental infections, pathologies of the sinus, like tumors, polyps and cysts are counted as such. However, cysts that are smaller than 10mm cannot be regarded as a contraindication because they can be treated during the surgery, utilizing suction. A known history of sinus surgery is also stated as a relative contraindication.(34) Other than that, the osteotome approach should not be chosen when the residual bone height amounts to less than 5 mm.(33)

5.DISCUSSION

5.1 Success rates

When analyzing the results gathered about the success rates of ITDIs, it can clearly be noticed, that the differences between the different authors occur according to the following tendency: The longer the follow-up period, the lower the success rate. Even though, the success rate is still very high after 10 years, with 93,75% and 94,8%. (21–25,36) There is only the study of Szabó et al that reaches a 100% success, even if they included patients with different types of underlying conditions.(26) This is surprising, since, as mentioned before,

several authors claim that underlying pathologies impact any implant intervention. For proper evaluation, it would be necessary to have precise information regarding the compromising conditions. Anyways, this makes clear that the insertion of ITDIs seems to be a predictable therapeutic option with a very high success rate, on the short-, middle- and long-term. However, one author labels the insertion of ITDIs as unpredictable (28) and long-term data is still scarce.(24) With respect to the studies reviewed about the sinus lift techniques, there is a bigger range of success rates according to the different authors that cannot be reasoned with different follow-up times. Reason for that might be the way, how the studies showing the lowest survival rates, were conducted. The publication of Barbato et al included a high percentage of 41% of smokers and patients, presenting with an RBH <4mm that is identified as a high-risk factor for failure in the same article. The study of Devameena et Dinesh was especially conducted in order to evaluate the difference between smokers and nonsmokers. In comparison with the other results, and in agreement with the statements of three other studies, smoking can clearly be called a factor that decreases the survival rate of implants on the middle- and the long-term.(27–29) The study of Tartaglia et al, besides showing a decreasing survival rate over time, just like in the case of ITDIs, indicates that proceeding with the SFE without inserting a bone graft contributed to a lower probability of success.(29) The fact that the study of Romero-Millan shows only a 44% success after 12 years, could falsely lead to the conclusion that the lateral window approach has a bad long-term prognostic, but it can be reasoned by only closely following up problematic implants over such a long period.(30) It can be added that Testori et al states that most of the implant failures occur during the first two years.(21) This is confirmed by Romero-Millan et al, in case of SFE with simultaneous loading, since it shows a significant drop of survival in the year and stays constant after that, (30), as well as Tartaglia et al, in case of the lateral window approach with grafting.(29) On the contrary, the rest of the studies show a gradual decrease of survival over time rather than a significant drop within the first two years. Moreover, the only study that directly compares both techniques under investigation, confirms the conclusions that can be taken with the individual results found, that the survival rate of tilted implants can overall be considered slightly higher than the

one of the SFE. Following, this conclusion can be regarded with a high grade of evidence because surely Gherlone et al had the same definition for implant success in both cases. Furthermore, according to the reviewed articles, smoking decreases the success rates of both options, whereas it has a bigger negative effect on SFE than on ITDIs.(21,27,28) This agrees with the fact that in the study of Gherlone et al the success rates of SFE appear to be slightly higher than in other studies, since they excluded smokers from the investigation.(31,38) Talking about the prosthetic survival rate, there are no differences detectable between the different approaches, since all studies considered present values between 99%-100%. It seems like the prosthetic aspect is not crucial to be included into the decision making between these two techniques. Literature gives a controversial answer to the question if the most common complication during an SFE, the perforation of the Schneiderian membrane, influences the survival rate and the long-term complications, even after the correct realization of the protocol. According to Bacevic et al, it does not lead to a more common failure of the implant. In contrast to that, Kim and Jung only agree on that for perforations that are smaller than 5 mm and state that, depending on the size, survival rate is decreased.(21,32,34,35)

5.2 Complications

Even if the different studies don't agree on the impact on the survival rate of the membrane perforations, they do agree on the fact that it is the most frequent biological, intrasurgical complication of the sinus lift technique with a range of 10-44%. This number cannot be seen as a very predictable value, since the technique of the surgeon makes a big difference. Special care must be taken in smokers, since cigarette smoke does make the Schneiderian membrane thinner and therefore more fragile. About the management, literature gives a slightly contradictory indication. Even if all the reviewed studies agree on an immediate fixing of the issue as the best option, Bacevic et al points out a large tear as an absolute contraindication for the continuation of the procedure. Kim et Jang simply give a decreased survival rate value of 74,14%, but do not contraindicate it. Although Bacevic et al and Beck-Broichitter et al show that after such occurrence the success rate is identical, it should be

considered a valid information, that the bigger the tear in the membrane, the bigger the risk for extrusion of the graft material, wound infection, a sinusitis after the surgery and the failure of the implant.(33,35) Two studies are of the same opinion that in case of a rupture and a planned one-step surgery, the prognosis is better when changing to a two-step surgery.(33) Mentioning hemorrhage during the procedure, one author calls it the second most frequent complication of a lateral window approach, even though other authors did not experience it frequently.(32,34) All techniques present with the risk of minorly frequent complications like the idiopathic damage of adjacent teeth, the cortical breakage and others, as mentioned before.(29,38) It is out of question that the most common complications are pain, edema, hematomas and infections posterior to any type of implant surgery, even though generally, they persist the longest after a direct sinus elevation technique since it is the most invasive.(32,33) The opinions of Gherlone et al and Kim et Jang coincide about the fact that BVVP only appears in patients where the transcrestal approach was utilized and usually resolves by itself.(33,34) When it comes to peri-implantitis and peri-mucositis after an implant placement, mentioning a coinciding definition for either of the diseases, the values that are given by the different authors are hard to compare, since follow-up times are varying a lot. But it can be observed that the prevalence of peri-implant mucositis is higher than the one of peri-implantitis, since it is the previous stage. No significant differences can be evidently pointed out between the different techniques. Most importantly, it needs to be kept in mind that the periodontal disease, around implants or natural teeth, depends on a variety of factors, as the patient's hygiene, the stress level and the oral microflora far before the angulation of the implant or the technique used to place the implant.(21,23–25,27,31,35) Since smoking is described as a risk factor for the Schneiderian membrane rupture, it can be concluded that it increases the risk for intrasurgical complications. When it comes to postsurgical issues, the results are not as clear. As explained before, according to Barbato et al, other than for the survival rate, smoking does not have an impact on the incidence of postoperative complications. This statement might be seen as contradictory, because according to Kim et Jang, smoking does increase the risk for membrane perforation (34) and since Hopp et al found that there is an

increased risk of wound infection, extrusion of the graft and sinusitis (37), it cannot be evidently said that smoking has no impact on the appearance of postsurgical complications, when using the direct SFE approach. The following factors were mentioned as potential risk factors for an increased MBL: increased age, smoking and underlying conditions, the location of a premolar and distally angulated implants. In the study of Menendez-Collar the results found were worse in case of smokers and the age group above 55. (36) Just like Szabo et al, Hopp et al, who indicates that suffering from a CDV increases the chance of suffering from excessive MBL, indicate smoking as a risk factor as well. (24,26) In contrast, in the article, that presents the lowest values of MBL, no negative impact of smoking was noted and included a sample with a relatively old mean age of around 65 years.(25) One other study also points out, not having detected a correlation between advanced age and a higher MBL. Only one of the reviewed publications states that each factor, premolar location, distally tilted implants, being a female, and suffering from a CVD, contributes to an advanced MBL.(20,35) Two of the reviewed studies give values concerning the MBL after the SFE. They agree on the amount of around 1,5mm after a 5-year period, no matter if the direct or the indirect approach is used. No risk factors for an increased MBL are found by these studies, but Qian et al found that there is a greater reabsorption during the first 3 years, which then stabilizes. Szabo et al indicates that the amount of bone resorption is higher with the SFE than in case of the placement of ITDIs, because the bone graft is resorbed easier than native bone. This matches the results that we obtained in numbers.(26,36,38) When analyzing the frequency and order of prosthetic complications regarding the two techniques, it must be underlined that, just like in the case of peri-implant mucositis, the choice of the surgical technique does not really determine the appearance of such. It depends more on the prosthetic handling and other factors, that were not deeply analyzed in the reviewed articles. As a tendency, bruxism and the material of the antagonist teeth could be identified as influencing factors. The results conclude that chipping of the esthetic porcelain layer, the decementation and loosening, as well as the fracture of the provisional or even the definitive prosthesis are the most common prosthetic complications to appear. Even if, by the results, no major, evident difference between one or the other

technique is suspected, for a good evaluation, further studies would have to be conducted and reviewed, that focus more on the prosthetic aspect.(21–23,25) Overall, literature agrees, that a precise diagnostic, clinically as well as radiographically with different projections and CBCT, is essential in order to predict potential risks, special conformations of teeth or the sinus and locations, where special care has to be taken to decrease the complication rate.(33)

5.3 Indications and contraindications

As already mentioned, this cautious pre-treatment evaluation is just as important in order to be able to choose the technique that is indicated. The study of Gherlone et al gives a clear overview about when to choose which technique. In case the residual bone height is lower than 5 mm, the only indicated technique is the lateral window approach. Above 5 mm, the transcrestal approach can also be performed. ITDIs are only indicated when there are at least 7mm of vertical bone.(33) There were no articles found that contradict their statement. In agreement with that, Menendez-Collar et al only included patients with a minimal (RBH) of 8mm for ITDIs.(36) The reason therefore is, that even with the maximum angulation of an implant, not much more than 3 mm of height can be compensated. By gaining 5-9 mm through SFE, even ridges of a vertical height of less than 4 mm can be augmented, so that an implant of minimum 10 mm can be placed. Agreeing with Menendez-Collar et al, that ITDIs have a slightly higher survival rate and a smaller range and frequency of complications, whenever the bone volume allows, ITDIs are recommended. As mentioned before, with elderly people who are known to be more prone to suffer from infections with a lower toleration to operative complications as well as long procedures, this indication is even more valid. Even though, it must be kept in mind that the older the patient, the higher the probability that the bone height in the posterior maxilla is insufficient for the insertion of tilted implants.(29) Comparing the two sinus elevation techniques, the transcrestal approach was developed with the goal of decreasing the trauma, but literature still indicates the direct approach as more predictable and it covers a broader range of indications, since it is recommended in case of more severe bone

loss.(33,39) In terms of contraindications, the reviewed literature gives coinciding information, that in case of a severely compromised general health state, as through an advanced CVD, uncontrolled diabetes, drug or alcohol addiction and cancer, especially being treated with IV biophosphonates, any type of surgery should not be done. Less severe factors, like smoking or bruxism are more controversial and depend on their severity. With respect to smokers, the literature review makes clear, that it is very controversial whether it is seen as a contraindication. Heavy smoking might be considered an absolute contraindication for the implant placement due to the high risk of osteonecrosis and therefore, the much lower success rate.(38) In the case of regular smoking, as listed in the results section, different authors do not share a common opinion because the success rate is not drastically reduced. To conclude, it might be seen as a relative or partial contraindication, just like Kim et Jang states, since the survival rate in smokers is generally described to be decreased, when performing the sinus floor elevation even more.(21,26,34) As a finding from this review it can be said that, in case of sufficient bone levels, ITDIs are rather indicated in smokers, because of a lower decrease of success rate and the better healing of less invasive procedures. Besides, the risk of membrane rupture, that is higher in smoking patients, can be avoided. If there is less than 7 mm of vertical bone present and the only option to place implants is to perform a sinus lift, the lateral window approach should be chosen, because in case of a tear, it could immediately be fixed. Other than that, the surgery should be planned in two steps.(32,34,35) Also bruxism is a partial contraindication for any type of implant rehabilitation in bruxist patients with insufficient alveolar bone levels in the posterior maxilla. When it is still chosen, specific guidelines should be followed.(39,40)

6.CONCLUSION

Generally, it can be said that these two procedures extend the aim group greatly when it comes to implant rehabilitations, allowing the inclusion of patients with great bone resorptions in the posterior maxilla. Even though more long-term studies are required, especially for ITDIs, it was found that both treatment options present with very high success

rates, in case of ITDIs slightly augmented. For the ITDIs, success rates of 92,4%-100% during a follow-up of 2-11 years found, whereas for the SFE they were 65,3%-100% during a follow-up of 1-11 years. The SFE, more specifically the lateral window approach, presents with a higher range and frequency of intrasurgical as well as especially short-term postsurgical complications. The indications are mostly based on the residual bone levels. In case of more than 7mm of RBH, ITDIs are indicated. With a lesser amount, an SFE should be chosen, the direct approach having broader indications. Other than that, contraindications are similar for both techniques and focus mostly on general conditions as well as local infections of the patient. Also, it is important to keep in mind, that a detailed pre-surgical clinical and radiographical examination, including a CBCT, is crucial for an adequate treatment choice, planning and outcome. Lastly, the experience and skillfulness of the surgeon widely impacts the outcome and prognosis, as well as the occurrence and management of complications.

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