GRADUATION PROJECT

Degree in Dentistry

SURVIVAL RATE BETWEEN PLATFORM SWITCHING VS DIRECT IMPLANT RESTORATIONS IN UNITARY IMPLANTS

Madrid, academic year 2022/2023

(1)

Identification number: 224

ABSTRACT:

Introduction: The use of new implant designs, such as platform switching implants and direct implant restorations have become more popular in recent years. It is important to evaluate which treatment option results a better survival and success rate and better preserves the peri-implant bone in case of single tooth missing. **Objectives:** The first objective was to compare the survival rate between platform switching implants and direct implant restorations, the second one was to analyze the success rate between them and the third objective was to evaluate the peri-implant bone level in both implant designs. **Material and methods**: Search strategy based on online catalogs (Medline, Biblioteca Crai Dulce Chacon) by using MeSH terms and a search strategy based on the focused PICO question. The selection of the articles focused on the inclusion and exclusion criteria, the whole texts of the relevant publications were obtained. **Results:** A total of 15 articles have been analyzed: 10 articles collected data for Platform Switching group and 5 studies about direct implant restoration group. Regarding the survival rate all the 15 articles provided data about it, instead regarding the success rate only 5 of them. All the articles provided the mean bone loss value during the follow up period. A range of 88.6% -100% survival rate in Platform Switching group and a range of 91%-100% in case of Direct Implant restoration group. The success rate was only evaluable in the Platform Switching group with a range of 97.1%-100%. In both groups the mean marginal bone loss was of 0.50 ± 0.70 mm each year. **Conclusion:** High survival rates were found in both groups and similar values regarding the peri-implant bone loss. A high success rate was found in Platform Switching implant group. Further studies with longer follow up periods are needed.

Keywords: Dentistry, Platform Switching implant, Direct implant restoration, Survival rate, Success rate.

RESUMEN:

Introducción: El uso de nuevos diseños de implantes, como los Platform switching implantes y Direct implant restorations o Implantes monofásicos, se ha vuelto más popular en los últimos años. Es importante evaluar cual tratamiento resulta en una mejor tasa de supervivencia, éxito y preserva mejor el hueso periimplantario en caso de que falte un solo diente. **Objetivos:** El primer objetivo fue comparar la tasa de supervivencia entre los Platform switching implantes y Direct implant restorations, el segundo objetivo fue analizar la tasa de éxito entre ellos y el tercer objetivo fue evaluar el nivel óseo periimplantario en ambos diseños. **Material y métodos:** Estrategia de búsqueda basada en catálogos online , utilizando términos MeSH y la pregunta PICO. La selección de los artículos se centró en los criterios de inclusión y exclusión. **Resultados:** Un total de 15 articulos se incluieron, con 10 artículos sobre Platform Switching y 5 para el grupo de Direct implant restoration. En cuanto a la tasa de supervivencia los 15 artículos aportaron datos al respecto, en cambio en cuanto a la tasa de éxito solo 5 de ellos. Todos los artículos dieron el valor medio de pérdida ósea durante el período de seguimiento. Un rango de tasa de supervivencia de 88,6 %- 100 % en el grupo Platform switching implantes y de 91 % -100 % en el caso del grupo Direct implant restoration. La tasa de éxito solo fue evaluable en el grupo Platform Switching de 97.1%-100%. En ambos grupos la pérdida ósea marginal media fue de 0,50±0,70 mm cada año. **Conclusión:** Se encontraron altas tasas de supervivencia en ambos grupos y valores similares en pérdida ósea periimplantaria. Se encontró una alta tasa de éxito en el grupo de implantes Platform Switching. Se necesitan más estudios con un período de seguimiento más prolongado.

Palabras clave: Odontología, Platform Switching implantes, Implantes monofásicos, tasas de supervivencia, tasas de éxito.

INDEX

1 INTRODUCTION

1.1 Implant definition and different solutions for replace a single tooth missing

Implant supported prostheses could represent a rehabilitative treatment choice for a single missing tooth (1). Dental implant is made of a biocompatible material and is inserted inside the maxilla or mandible through surgery and allows to subsequently support an artificial tooth crown, this permits to replace an absent tooth due to a periodontal problem, caries, accidents or other reasons(2). Many other types of prosthetic treatments modalities are available such as removable dental prosthesis, fixed dental prosthesis; the preferences of both patients and dentists about treatment choices are related to several variables, including refusal to undergo surgical treatments, duration of therapy, cost, the condition of the adjacent teeth. Mainly, damage to the adjacent teeth like in case of fixed dental prothesis with abutments preparation, and cost were the most significant among the many factors that influenced the patient's choice of the final treatment approach. In the implant group, there was more aesthetic and functional satisfaction than in the removable protheses group. The patient's degree of education and understanding of available treatment options for a single missing tooth have a big impact on the treatment option (1). Dental implants can be defined as the best, most recent, and most sophisticated method of replacing missing teeth, from a single tooth to a complete arch rehabilitation (3)

1.2 Main types of implants-abutment connections

Dental titanium implants, made of two pieces, have been used often (4). By definition: “Two-piece implant is an implant consisting of an implant body and a separate abutment” (5).The implant abutment interface (IAI) must be stable in order to sustain functional loads, decrease screw loosing and resist dynamic stresses (6). For that reason, various IAI geometries have been created to ensure the connection's stability, and they are summarized into two big categories: internal and external. The external connection is defined as “an abutment connected to the implant by an abutment screw”(7). This connection is also known as a butt joint interface because the flat area on the top of the implant and the bottom of the abutment are in continuous contact. The abutment screw's tightening stabilizes this external connection totally and connects the implant

with the abutment so it elongates when torque is applied, creating a preload. The preload provides a force that clamps the IAI that gives the connection stability (7). The external connection is often related to an outside hexagon, the purpose of which is to limit rotational torque during implant insertion (8). In case of internal connection type, the abutment screw preload is not the only preload applied, stability is maintained through intimate contact between the inner surface of the implant and the outer surface of the abutment. Frictional force, which is produced by the close contact between the abutment and implant, is important to maintaining the integrity of the connection. As a result this type of connection is also known as a friction-screw-retained connection, the amount of tapering at the interface in between implant and the abutment is a significant factor (7).

1.3 Peri-implantitis, peri-implant mucositis and marginal bone remodeling

For the restoration of two-stage implants that also includes internal and external abutment connections, it has proven challenging to prevent microbiological leaking at the IAI in order to minimise inflammatory responses and increase bone stability surrounding the implant because it has been well documented that a contaminated micro gap exists (9). For this reason, it is important that the biological soft tissue made by the peri-implant soft tissue complex, which is composed of a junctional epithelium and connective tissue, covering the bone surrounding the implant of 3-4 mm in width is present (10). Therefore, it is crucial to maintain this firm soft tissue seal to stop microbial invasion and peri-implant diseases which includes peri-implant mucositis that is a condition in which, after initial bone remodeling during healing, inflammation is only present in the soft tissues around a dental implant and there are no symptoms of supporting bone loss. Instead, when there is peri-implantitis, there is inflammation of the soft tissues surrounding the implant as well as a progressive loss of supporting bone that goes beyond normal bone remodeling (11). Bone loss occurs at the first point of contact between the implant and the host bone, causing an apicalization of the crestal bone if the peri-implant area becomes infected with bacteria, which results in creating a permanent kind of inflammatory connective tissue. The amount of bone loss depends on whether the patient is vulnerable to infection-related bone loss related to the host immune response. Both the magnitude of this micro gap and the existence of

movements between the implants and abutments might be important. Additionally, the micro gap causes micromovements at the IAI, which affects how much stress is placed on the surrounding bone and accelerates crestal bone resorption. Implants with matching diameter between the implant platform and abutment connection, considered the most used, appear to have a biologic dimension of hard and soft tissues that surrounds them that extends apically from the IAI, according to histologic and radiographic findings. The vertical repositioning of crestal bone and consequent soft tissue attachment occur when an implant is exposed to the oral cavity and corresponding diameter restorative components are attached (12).

1.4 Platform switching implant

This biological response from the hard and soft tissue around the IAI produce the inspiration for research into implant system designs that offer a reduction in the exposition of bacteria at the IAI in an effort to obstruct microorganisms and less inflammation so prevent bone loss. Marginal bone loss as well has been hypothesized to rely on a number of variables, including the implant neck surface properties and the implant-abutment connection (9). For this reason, the concept of platform switching (PS) was introduced by Lazzara and Porter in 1991 and refers to: “the use of a smaller-diameter abutment on a larger-diameter implant platform” (Figure 1).

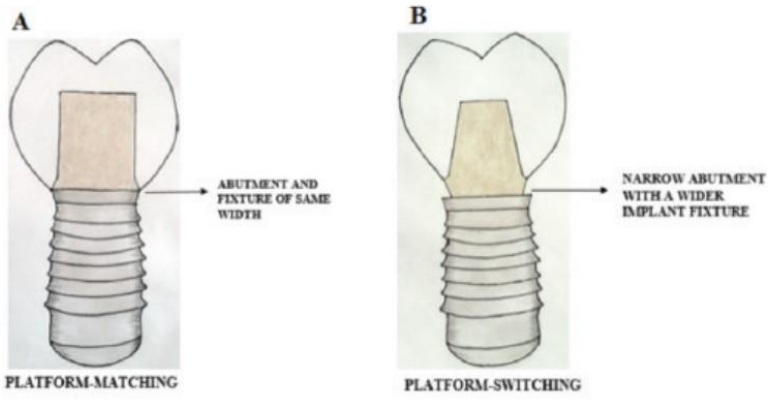

Figure 1: Platform matching implant (A) , Platform Switching implant (B). The image underlines the size discrepancy as a result of the use of a narrow abutment with a wider implant platform (B) compared to a matching size between abutment and implant (A) (13).

The contact between the implant and the connected component element has traditionally been located at the outside border of the implant platform so when two-piece dental implant systems have been reconstituted with prosthetic components, it creates a matching implant-abutment connection. The concept of PS was introduced when casually a wide diameter 5.0 mm and 6.0 mm implants and matching 5.0 mm and 6.0 mm diameter sitting surface were planned in 1991 trying to achieve an increased primary stability. However, commercially, matching-diameter prosthetic components were not accessible of this dimension, therefore many of the 5.0 mm and 6.0 mm wide implants were restored with "standard" diameter (4.1 mm) prosthetic components. The size discrepancy between the prosthetic component's diameter and the implant's seating surface diameter in circumferential horizontal direction was of 0.45 mm and 0.95 mm (14). In this way a smaller prosthetic abutment are positioned on the implant platform and move the IAI away from the bone and inward from the implant platform (10). The position of the micro-gap has changed, which may modified the infiltration of inflammatory cells area and thus result in the reformation of biological width (15). The surface area for soft tissue adhesion is also increased by moving inward the IAI and as consequence also on the mechanical transfer of the load, which in turn affects peri-implant marginal bone (16). According to the literature, there are some advantages and disadvantages in the use of this type of implant.

Advantages:

1. Preservation of Peri-Implant Bone: as previously mentioned preserving the peri-implant bone is one of the key benefits PS implants. This is due to the fact that there is a gap or "switching platform" between the implant and abutment since the abutment diameter is less than the implant diameter. It may be possible to avoid bone loss and preserve the integrity of the implant by reducing stress and micro-movements at the implant-bone contact with the aid of this gap. Compared to matching platform implants, PS implant reduces marginal bone loss (17).

2. Better Soft Tissue Management: PS can also aid in better soft tissue care surrounding the implant area. In order to produce better soft tissue healing and lower the risk of problems including implant failure, implantitis and peri-implantitis, the space between the implant and abutment can function as an area that decreases pressure on the surrounding soft tissues (18).

3. Improved Esthetic Results: This type of implant platforms can also lead to better aesthetic results, especially in the front maxilla. The space between the implant and abutment can aid in producing a more natural emerging profile and providing greater support for the soft tissues, both of which can improve the aesthetic of the implant restoration with the neighboring natural teeth. Compared to conventional platform implants, PS implants produced better aesthetic results(18).

4. Increased Restorative Adaptability: Compared to conventional platform implants, PS implants can provide better restorative flexibility. In this way the dentist may obtain better implant angulation, emergence profile so a better restoration. The space between the implant and abutment enables greater freedom in the positioning of the prosthetic components (6).

Disadvantages:

1. Restricted availability: The limited availability of PS implants is one possible limitation. Despite the fact that many implant producers now provide PS implants, these implants could not be offered in all shapes and sizes, which might restrict their application in particular clinical circumstances (15).

2. Increasing technical difficulty: this is due to the fact that the space between the implant and abutment needs to be carefully managed to guarantee good fit, alignment, and stability. The dentist may need to put in more effort and have more knowledge and experience to accomplish this. Comparing PS implants to conventional platform implants, PS implants needed more often abutment re-tightening and more exact abutment seating (15).

3. Increased cost: comparing PS implants to conventional platform implants might result in higher costs. This is partly because there aren't many PS possibilities and the implant-abutment relationship commercially available (10).

1.5 One-piece implant or direct implant restoration

Another type of implant design that prevents the existence of the micro gap between IAI: one-piece implant also called direct implant restoration(DI) or one-body implant, in which by definition: “the bone anchoring unit and a contiguous transmucosal component are created in one piece” (19), Figure 2.

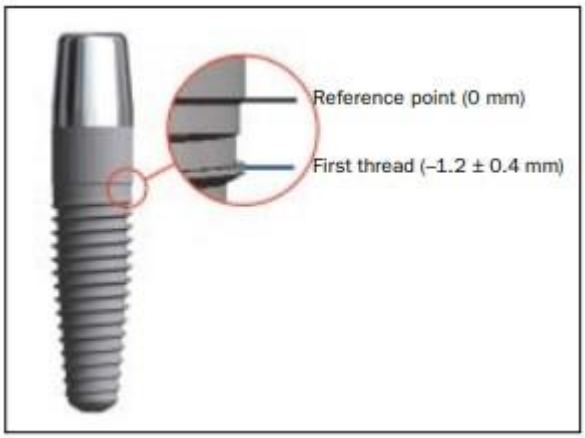

Figure 2: One piece implant composed by a bone and transmucosal component, the space between the reference point and the first thread is usually used as reference of the bone level(19).

The DI implant system is designed to be employed in single-stage surgery, in a non-submerged implant healing type, that extends above the bone and passes through soft tissues so exposes to the oral cavity (20). An additional benefit may be the absence of gaps or micromovements at the IAI, which have been considered to be harmful to the peri-implant soft and hard tissues (21). After initial healing, this design prevents changing the soft tissue interface and also avoids the necessity to place abutments later. The implant's preparable abutment section enables preparation and the fabrication of custom shapes to satisfy functional and aesthetic requirements without compromising the soft tissue seal. Also, if the edentulous ridge may not be wide sufficiently in the front jaw, narrow-diameter DI implants provide great results. It may be assumed that this reduces, in some cases, the need for invasive reconstructive techniques such grafting procedures(20). Compared to conventional two-piece implants, this method has a lot of benefits, but there are also some possible disadvantages to take into account. According to the literature there are advantages and disadvantages.

Advantages:

1. Faster functional rehabilitation: DI implants may be utilized for functional rehabilitation more quickly than two-piece implants since they can be loaded immediately(22).

2. Shorter treatment time: DI implants may be placed more rapidly than two-piece implants since they don't need a separate abutment attachment process. This shortens the overall treatment time (22).

3. No harm to nearby tissues: DI implants don't need to employ healing caps or other parts that might harm the tissues in the area around them. DI implants are preferable in cases where space is restricted since they need less than two-piece implants (19).

4. Patient compliance: Due to less visits, patients tend to be more cooperative with DI implants than two-piece implants (22).

5. Fewer micromovements: DI implants have less micromovements since there isn't a connecting screw, which can reduce avoid implant failure (19).

6. Excellent soft tissue healing: DI implant's shape encourages optimal soft tissue healing (21).

Disadvantages:

1. Restricted options: DI implants can only be used in a limited range of clinical settings since they are only available in a limited range of sizes and forms (22).

2. Limited customization: Because DI implants are a single item, the abutment's form, angle, or depth may only be slightly altered (5).

3. Possibility for fracture: DI implants may be more prone to fracture than two-piece implants, especially in instances when excessive force is applied (5).

4. Compromised stability: when the implant site is not optimal or the implant is positioned at an angle, DI implants may not be as stable as they should be (5).

5. Risk of infection: as DI implants are harder to clean than two-piece implants, the likelihood of infection or other problems may be increased (22).

6. Limited research: DI implants have little long-term study, which may cause some dentist to be cautious to utilize them(19).

In summary, DI dental implants provide a number of benefits over conventional two-piece implants, including quicker functional rehabilitation, a shorter recovery period, and better utilization of available space. They do, however, have a few possible problems, such as restricted selection, cleaning difficulties and fracture risk. In the end, the choice to utilize DI implants should be based on the specific requirements of the patient and accurate analysis of the advantages and disadvantages (5,21).

1.6 Osteointegration failures

In the middle of the 1960s, BRANEMARK proposed the concept of osseointegration, which helped oral implants have predicted long-term success. By definition given by ALBREKTSSON is: “direct functional and structural connection between living bone and the surface of a load-bearing implant” (23).

According to Esposito (23): biological, mechanical, iatrogenic, and adaptive failures are the different categories of implant failure. Early and late biological failures are categorized according to how they relate to the conditions that influence bone healing and overall health. Mechanical failures include part or implant breakage. Iatrogenic failures are related to implant failure related to anatomical features violations such as the inferior alveolar nerve damage, incorrect implant positioning. Implant failure can be considered also in case of insufficient adaptation or including the patient's aesthetic displeasure and psychological issues (24).

1.7 Implants success and survival rate

DI and PS implant have been developed and commercially available on the market as a result of the improvement of the implant designs.

Implants are frequently evaluated on the basis of success and survival rate, where "success" denotes whether the examined implant satisfies the success criteria, while "survival" only denotes the implant's presence in the mouth(25).

Albrektsson and colleagues (26) provided the universally accepted criteria for the assessment of implant success in order to find clinical evidence of successful osseointegration and as well implant survival (27):

1. A clinical test demonstrates that the implant has no mobility.

2. That a radiograph shows no signs of peri-implant radiolucency.

3. “That after the implant's first year of loading, vertical bone loss be less than 0.2 mm overall”.

4. That each patient's implant is characterised by the absence of any chronic or permanent symptoms, including discomfort, infections, neuropathies, paresthesia, or mandibular canal violation.

5. That a successful rate of 85% at the conclusion of a five-year observation period and 80% at the end of a ten-year observation period be a minimum standard for success

Since then, new criteria for measuring the success of implant restorations have been devised. These parameters include overall health, peri-implant soft tissues if seem to be natural, prosthodontic parameters and patient satisfaction. Osseointegration, however, remains to be crucial and the most important criteria in implant dentistry. The present definition of success criteria incorporates these other factors (27). The systematic review conducted by Papaspyridakos et al (28) analyzed a total of 128 studies to identify the present success criteria in implant dentistry. Based on their analysis, the authors propose the following success criteria (28):

1. Implant Survival: Implant survival is the percentage of implants that are presently in situ and working at the time of evaluation. The success percentage for implant survival is commonly stated at a minimum of 90% throughout five years of follow-up.

2. Implant Success: Added to implant survival, the word "implant success" refers to a broader idea that encompasses patient and clinical results. Over a 5-year period, implant success rates are normally established at a minimum of 85%.

3. Marginal Bone Loss: Marginal bone loss is the amount of bone remodeling around the implant. Different success requirements for marginal bone loss

depend on the implant location and loading conditions, but in general, mean bone loss should be "less than 1.5 mm after the first year of loading and less than 0.2 mm after the first year."

4. Implant Stability: Implant stability has a big impact on an implant's success. It is common practice to set the minimum implant stability success requirement at 30 ISQ (implant stability quotient).

5. Health of Peri-implant Soft Tissues: The success of implants is significantly influenced by the condition of the peri-implant soft tissues. The minimal success criterion for peri-implant soft tissue health is commonly described as the absence of peri-implant inflammation or bleeding after probing.

6. Prosthetic Function: The restoration supported by implants' ability to carry out a prosthetic function. The lowest success criterion for prosthetic function is frequently the lack of any aesthetic or functional problems.

7. Patient satisfaction: A successful implant depends on the satisfaction of the patient.

8. Quality of Life: An essential factor in the success of an implant is how the procedure will affect the life of the patient. The standard for success is often established at the oral and dental health-related quality of life improving or being constant.

9. Adverse Events: Any issues or unfavorable responses connected to implant therapy are referred to as adverse events. The lack of major adverse events connected to the implant therapy.

Finally, the success criteria used today in implant dentistry includes not just implant survival but also clinically and patient-reported results, giving importance to the effect of implant therapy on the patient's quality of life (29). These criteria offer a thorough set of measures for assessing implant success and as well survival rate to choose the best implant type between PS and DI in case of single tooth missing.

2 OBJECTIVES

2.1 First objective

Compare the survival rate between platform switching implant and direct implant restoration in case of single-tooth replacement.

2.2 Second objective

Analyze the success rate of platform switching implant and direct implant restoration.

2.3 Third objective

Evaluate the impact on crestal bone level in case of platform switching implant and direct implant restoration.

3 MATERIALS AND METHODS

A bibliographic review was performed on MEDLINE and CRAI "Dulce Chacón", as well some articles were founded from the bibliography of some relevant publications. The research question was formulated by means of a PICO:

P—single titanium implant.

I— platform switching implant.

C— direct implant restoration.

O— survival and success rate.

Key words and their combinations were utilized to find research published till December 2022, according to the syntax requirements of each database. Electronic search was performed following MeSH (*) or Free Text (#) words were used:

[“dental implants, single tooth” (*) AND “one-piece implant” (#) OR “monotype implant”(#) AND “Platform Switching, Dental Implant” (*) AND “survival rate”(*) OR “clinical outcome” (#)] [“dental implants, single tooth” (*) AND “one-piece implant” (#) OR “monotype implant”(#) AND “Platform Switching, Dental Implant” (*)AND “success rate”(*)] .

3.1 Inclusion criteria

The publications selected were required to be in English or Spanish, include a complete text and abstract and have at least a 12-month follow-up after the implant was placed in order to be included. Articles that examinate the survival and success rate of platform switching implant compared to direct implant restoration; articles that analyze the survival rate of each of them and that include in the text the value of marginal bone loss around the implants. Another inclusion criteria were articles following patients not affected by systemic disease that could interfere with the survival, success rate of the implants and their bone remodeling process.

3.2 Exclusion criteria

Articles that study case reports, case studies, animal studies, and laboratory research are excluded from consideration. Also, if the patients included were not received a clinical examination throughout the follow-up period, articles more than 10 years were also discarded. Studies using several implant systems or kinds that did not clearly distinguish one from the other were also excluded.

4 RESULTS

4.1 Literature search

A total of 736 articles were found in the first literature search from MEDLINE 218 articles and CRAI "Dulce Chacón" 518 publications, no additional articles were founded through other sources. After removing duplicates, 715 articles remained. Then 643 irrelevant articles were disqualified, 72 suitable articles emerged after the review of the titles. As well papers' abstracts were reviewed, and after excluding 49 that were not relevant, the full texts of the remaining 15 articles were included, Figure 3.

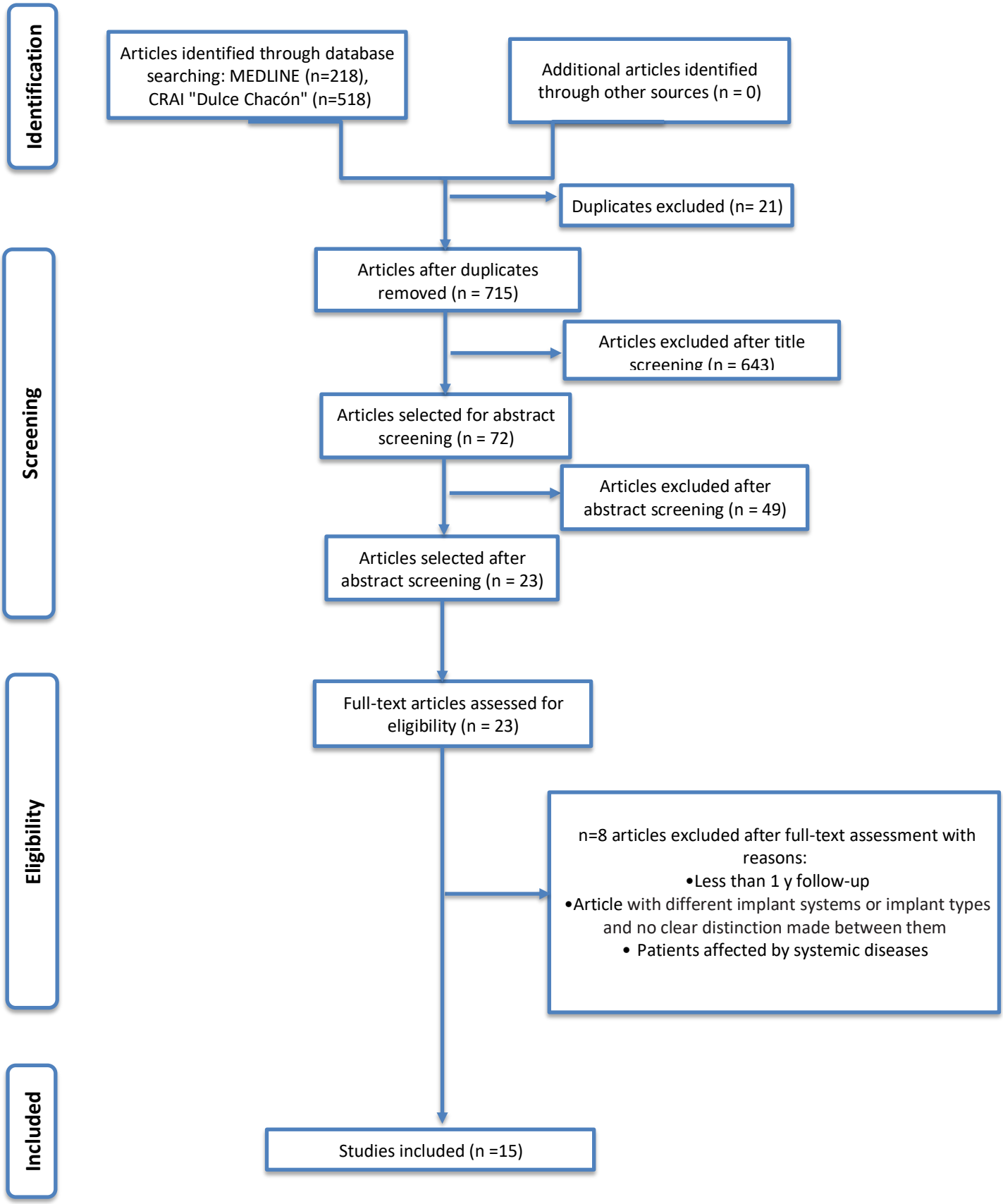

Figure 3: Prisma Flow Chart.

4.1 Data extraction

Data extraction was performed. The data included were, Table 1: (1) Author and year of the selected articles, (2) number of patients involved in the study, (3) number of implants placed, (4) location: maxilla or mandible, (5) follow up period range, (6) healing period till the loading expressed in weeks, (7) test group: platform switching implant (PS), (8) control group: direct implant restoration (DI), (9) number of implants failed during the follow up period, (10) survival rate expressed in percentage, (11) success rate expressed in percentage.

4.2 Study description

All the data of the included publications are in Table 1. The selected studies were published between 2012 and 2022. The total number of patients who received the implants in the publications were collected and total number of implants placed too. All studies specify where implants were placed in mandibular sites or maxillary sites except Spinato et al(30), Cassetta et al(31). The follow up periods range between 1 to 10 years, the healing period before the prosthetic loading range between 6 to 24 weeks. A total of 10 articles collected data for PS group and a total of 5 for DI group. Regarding the survival rate all the 15 articles provided data about it, instead regarding the success rate only 5 of them. All the articles provided the mean bone loss value during the follow up period.

Autor/ Year	No. of patients	No. of implants	Maxilla/ Mandible	Follow-up time (range)	Healing period/ Loading (weeks)	Test group	Control group	Implants failed	Survival rate (%)	Success rate (%)
Aimetti et al (2015) (18)	40	58	34 maxilla 24 mandible	2 years	Not specified	PS	-	0	100%	100%
Beschnidt et al (2018) (32)	196	203	98 maxilla 105 mandible	1 year 3 years 5 years	6-12	PS	-	11	100% 99.6% 98.6%	100% 99.4% 97.4%
Guerra et al (2014) (33)	35	74	74 mandible	1 year	4-8	PS	-	2	97.3%	97.3%
Enkling et al (2013) (34)	25	50	50 mandible	3 years	Not specified	PS	-	0	100%	100%
Sanz-Martín et al (2017) (35)	47	61	30 maxilla 31 mandible	2 years	Not specified	PS	-	4	96.4%	Not evaluated
Nelluri et al (2022) (36)	90	90	45 maxilla 45 mandible	1 year 2 years 3 years	Not specified	-	DI	8	93% 91% 91%	Not evaluated
Ghaleh-Golab et al (2016) (37)	272	533	216 maxilla 317 mandible	1 year	Not specified	-	DI	12	98%	Not evaluated

Thoma et al (2014) (38)	30	65	Not specified	1 year	Not specified	-	DI	1	98.5%	Not evaluated
Finne et al (2012) (19)	56	82	26 maxilla 56 mandible	3 years	Not specified	-	DI	1	100%	Not evaluated
Kadkhodazadeh et al (2019) (20)	26	30	10 maxilla 20 mandible	10 years	Not specified	-	DI	0	100%	Not evaluated
Soldine et al (2022) (39)	50	90	47 maxilla 43 mandible	4 years	12	Morse tapered PS	-	0	100%	Not evaluated
Cassetta et al (2016) (31)	352	748	Not specified	3 years	24	Morse tapered PS	-	28	90%	Not evaluated
Spinato et al (2019) (30)	70	70	70 mandible	1 year	16	PS	-	4	97%	Not evaluated
Prati et al (2020) (40)	76	128	70 maxilla 58 mandible	4 years	12	PS	-	2	98.4%	97.65%
Ekstein et al (2016) (41)	37	112	49 maxilla 63 mandible	1 year	24	Conical tapered PS	-	0	100%	Not evaluated

Table 1: Data from 15 articles included in the study.

5 DISCUSSION

The aim of this study was to compare, through a bibliographic review, the survival rate and the success rate of PS implants versus DI implants in case of single tooth missing and to evaluate the impact on crestal bone-level of both implants geometries.

The first article analysed Aimetti et al(18) suggested that subcrestal positioning of PS implants is an effective alternative in prosthetic rehabilitation since it demonstrated adequate crestal bone stability and ideal aesthetics over the first two years of follow up, as inclusion criteria, all implants were positioned in areas with thick soft tissue (> 2 mm) because one of the variables influencing peri-implant bone remodelling was found to be the initial vertical soft tissue thickness. In that study, only two patients lost more than 1 mm of marginal bone between the implant's area during the 2-year after the implants placement resulting in a bone remodelling of around 0.32 mm. At the conclusion of the follow-up assessment, 12 patients (30%) had all of their implants with thick tissue on the platform. Over 40 patients 58 implants were placed of PS group giving 100% of success rate and 100% survival rate during 2 years of follow up. The publication of Aimetti et al (18) was a prospective case series, so one significant disadvantage was that it was not designed as a randomised controlled clinical study.

Instead the results of a multicentre randomized clinical trial can be analysed in the publication of Guerra et al (33) . After surgery, randomization was conducted. There were placed 74 PS implants in 35 patients and followed during 1 year. According to the study, the mean crestal bone level value changed from 0.40 to 0.46 mm between surgery and 12 months after loading. Similar value were found in case of DI group by Ghaleh Golab et al (37) in which, after a year, they detected 0.59 -0.41 mm of bone resorption. DI implants are developed with the goal of causing the least amount of bone resorption possible by removing the IAI and its micro gap and causing in the mucosa the least amount of irritation during the implant osteointegration. The first year following implant surgery is

when the majority of bone resorption may occurs with DI implants(21). As the biological component is analyzed, it indicates that bone resorption is associated to the recovery of biological width following microbial invasion of the IAI. Bone resorption and mucosa thickness are the main factors regarding the success and as well the survival rate of the implants (17). Guerra et al(33) found 97.3% survival rate and 97.3% of success rate for PS group with 2 implants failed during the 1 year of follow up. Instead Ghaleh Golab et al (37) during the same follow up period found 98% of survival rate in the DI group with 12 DI failed over 533 DI implants placed. It is important to know that, regarding the publication, the general practitioners were competent and trained so the study's findings should be evaluated carefully, taking this into account. It should be noted that the placement of DI implants in the upper anterior area may be difficult due to rigid and unchangeable abutments(37).

It can be demonstrated that bone density significantly affects the mean marginal bone loss, for that reason different survival rates values emerged in the maxillary anterior and mandibular posterior areas in the article of Nelluri et al(36). In this article patients with one missing maxillary anterior tooth and patients with one single mandibular posterior tooth received DI implants. After 1, 2, and 3 years of follow-up, respectively, three, one, and zero implants in the maxillary anterior area were lost, indicating a survival rate of 93% after one year and 91% after two and three years. Four implants were lost in mandibular posterior area, all during the first year of follow up, so a survival rate of 91% emerged after 1 year of follow-up and as well 91% of survival rate at the end of 2 and 3 years of follow-up even if no DI implants failed. Unfortunately, four implants in the mandibular posterior areas were lost. In this circumstance, a first-moment excess load may have caused bone loss, which resulted in discomfort and mobility problems. The subsequent bone loss that led to implant failure may potentially have been exacerbated by poor oral hygiene care. As well, the traumatic occlusion could have prevented osseointegration (36).

Taking this into consideration, it is crucial to interpret the articles aware that many factors can influence their success and survival rate, it does not always depend on the technique or type of implant used.

A follow up period of 5 years was conducted in the publication of Beschnidt et al(32), in which a total of 203 PS were placed in 196 patients, respectively in 98 maxilla and 105 in mandible, with a total of eleven PS implants failed and a survival rate of 100% during the first year, 99.6% during the second year and 98.6% during the fifth year. Regarding the success rate criteria, three failed to fulfil success criteria because of bone loss (n = 2) and peri-implantitis (n = 1), according to Albrektsson et al (26). This multicenter study of Beschnidt et al (32) analyzes the Plaque index, Sulcus bleeding index, Pocket probing depth, Jemt papilla score, Bone level changes, Prosthetic complications and as well Patient satisfaction. At each time point throughout the trial, more than 60% of patients expressed great patient satisfaction, and the other patients always reported positive results. The patient satisfaction should always be considered as an important criteria to assess the success of the treatment. Additionally, the traditional standard of bone loss being: “less than 2.0 millimeters during the first year of function and less than 0.2 millimeters annually”(28) after that may no longer be appropriate as a criteria for the success rate, especially with new implant systems like PS implants, which cause minimal crestal bone loss (28). From the publication of Beschnidt et al(32) emerged low crestal bone loss of 0.32 mm, which gave similar results as prior investigations on these implants. Taking into account the success rate, three implants failed after being loaded, and one implant failed because of peri-implantitis so the success rate for PS implants was 100% after the 1-year, 99.4% after 3 years and 97.4% after 5 years.

In the article of Enkling et al (34) the idea of an positive impact of PS on crestal bone level changes has to be confirmed based on the findings of the three-year follow-up. The first 16 weeks is the period in which the peri-implant mucosa is often altered, are the most important times for peri implant bone-level remodeling. The crestal bone level modification during the first months is common and has been established for a variety of implant systems (42).Enkling

et al (34) analyze the crestal bone level around 50 PS implants and found after 3 years radiographic crestal bone loss of 0.69 ± 0.43 mm around the implant, in addition no PS implants failed during the follow up with a survival rate and success rate of 100%. Despite this, the authors concluded that following the results obtained, the theory related to PS that would prevent bone resorption could not be supported since similar values were founded in case of standard matching platform implants. They suggest that the dentist who chooses the implant system, should follow the method and approach they feel is the best depending the case and their experience (34). Regarding DI implants group, Thoma et al(38) article showed lower levels of crestal bone at the implant level at beginning and one year later compared to the standard two-piece matching platform implant, -0.51 mm (0.93 mm) in two-piece implants and -0.75 mm (1.14 mm) in DI implant with a survival rate of 98.5% during 1 year of follow up with 1 implant failed of a total 65 DI placed.

After seeing these results, it is important to know that the remodeling processes that took place following implant placement differed significantly between one- and two-piece dental implants, which was one of the most notable discrepancies found (21). The remodeling mechanisms of the surrounding bone begins immediately after the implant is inserted for DI implants. On the other hand, in case of two-piece implants, the process starts following abutment loading. The cause of this variation was that two-piece implants had a micro gap, bacteria colonized the micro gap causing an inflammatory infiltrate. The degree of crestal bone loss in the area is correlated to the degree of the inflammatory infiltration (9). In an attempt to limit the infection, the epithelium moves beyond the bacterially-colonized surface, and bone resorption takes place to assure a subsequent creation of a soft-tissue connection of a 3 mm healthy biological seal around the implant's platform. Porter and Lazzara suggested the concept of PS to reduce this bone loss close to the IAI in case of two-piece dental implant. They believed that by moving the implant abutment junction inward, the micro gap/inflammation would be shifted away from the crestal bone and would allow for a little increase in the thickness of the horizontal soft tissue part and reduce

the crestal bone loss (14). According to the study Soldini et al(39) by using implants with PS and Morse taper connections, during the first year there was a mean bone alteration of 0.31 mm, and after four years, it was 0.45 mm. Just five implants lost more than 1 mm of crestal bone over the course of the four years, and four implants showed no evidence of radiographic bone loss at that time. The 100% survival rate in the study may be attributed to the properties of the implants used and as well the patients' meticulous adherence to the recommended maintenance therapy.

The same type of implants so PS and Morse taper connections was analyzed in the article of Cassetta et al(31), 748 PS were inserted over 352 patients. After 3 years of follow-up emerged a survival rate of 90% with 28 PS failed, results of four failures in the early period (1.14%), before prosthetic loading, 24 failures (6.86%) happened after prosthetic loading. A different result compared to the survival rate of 100% emerged in the article of Soldini et al (39). The different values in the 2 articles underlines the importance of the size of the sample analyzed, the greater will be the more reliable the results are.

There are a lot of factors that influence the survival rate and the osteointegration process. The early disruption of osseointegration can be due to high biomechanical stress (extreme mechanical axial or lateral forces) may cause periimplantitis. This stress will typically be the cause of the destruction of the osseointegrated interface, even though they sometimes also create the fracture of the prosthetic pieces or in extreme cases produce the implant rupture, that create the subsequent bacterial infiltration of the damaged areas and the development of granulation tissue, which is harmful to bone tissue and make this peri-implantitis-causing factor worse. The most challenging risk factors to manage are often the existence of natural antagonist teeth with parafunctions like bruxism or in case of reduced occlusal vertical dimension and prosthetic space. During the osseointegration process, the quality of the supporting bone is also essential against excessive mechanical stress. Theoretically, denser bone will be more capable to withstand severe masticatory stress, this explain why the maxilla experiences peri-implantitis more frequently than the mandible (43).

Cassetta et al (31) showed that PS implants for the first 12 months of osseointegration, implants placed in the maxilla became more problematic, the survival rate of patients with PS implants placed in the mandible and maxilla did not show statistically important differences. Incongruous masticatory stresses may have a higher negative impact on low-density bone only at the early phases of osseointegration. The study considers the use of PS with Morse cone-connection implants is a therapy strategy that is both secure and reliable (31). The type of prosthetic restoration, the implant length and the implant diameter are stress-related parameters that influence the likelihood of failure, demonstrating the importance of biomechanical considerations for the durability of osseointegrated implants. As a result, the dentist would be recommended to pay attention to these variables during the planning, surgical, and prosthetic stages of implant rehabilitation(31).

The same follow up period as Cassetta et al (31) with PS implants was followed in the article of Finne et al(19) that analyze the survival rate of DI implants. After 3 years a survival rate of 98.8% emerged in DI group (19) instead a value of 90% appeared in PS group (31). Is important to know that the result cannot be comparable because of the big difference in the size of sample between the two articles. The number of failed implants increased as the number of implants inserted and analyzed during that period, because as previously mentioned a lot of factors can influence the survival and outcome of the implant rehabilitation. The results can only be compared if the same sample and time are considered; otherwise, cannot be made.

The prospective multicenter research conducted by Finne et al(19) shows that one-piece oxidized-surface implant may osteointegrate with the same predictability as has been described in others clinical trials using the same type of implant. The success rate of the DI implant has been proposed to be influenced by in-situ preparation and insertion depth (26) (44). Prior to the placement of the prosthesis, 43% of the implant sites in Finne et al(19) research underwent to an intraoral preparation. No evidence was discovered; however, this treatment increased the risk of implant failure or changed the degree of

bone remodeling. This article clearly demonstrated a stability of the mean marginal bone level after the first year of function, in contrast to previously published findings on the examined one-piece implant system(26) (44) . At the 3-year follow-up visit, the mean marginal bone level was 0.79 mm apical to the reference point, located at the first thread of the implant. One patient had peri-implantitis, which had been preceded by bone loss and failure of soft tissue attachment to the implant site. Is important to take into account that this patient did not have an appropriate oral hygiene and was a smoker. In a total of 56 patients rehabilitated with DI implants, one diagnosis of peri-implantitis is not out of the ordinary prevalence for implant therapy. According to the literature, peri-implantitis prevalence ranged from 0% to 14% in various investigations (45). Implant placing may be restricted in terms of aesthetics due to a patient's unique anatomy, such as a thin mucosal biotype or scalloping of the peri-implant mucosa(46). Five patients in the Finna et al trial(19) reported adverse effects involving soft tissues, including soft tissue recession and mucosal visibility of the implant's metal color. In the study, the papilla score increased from insertion to 3 years at more than half of the implant locations that were assessed. The result of the article show that immediately loaded DI implants produce predictable effects within the limitations of that investigation (19). The survival rate for DI implants was of 98.5%. During the first year of function, the peri-implant mucosa and papilla sizes were stable, and only slight alterations in the bone level were seen(19).

Sanz Martín et al(35) compared to transgingival implant versus PS bone-level implants, the study's findings showed that in order to prevent changes in crestal bone level between implant insertion and loading, transgingival implants preserve it much better. Several causes may influence for this distinct behavior during implant osteointegration. First, the transgingival implant design's shown stability, it has been widely discussed in the literature and has showed consistent marginal bone levels one year (0.1 mm), five years (0.32 mm), and ten years after loading (0.86 mm). The increased early (before loading) bone loss of the two-piece PS implants was explained experimentally by infection that enter through

a micro gap at the implant to abutment connection, causing inflammation and crestal bone loss (12). The effects of abutment dis/reconnection may also be used to explain these variations between placement and loading in the bone level. According to the literature, as compared to the direct loading of definitive abutments during implant placement, the connection and disconnection of the abutments (one dis/reconnection) resulted in more bone loss. While the IAI was closer to the bone, it is possible that the prosthetic techniques used in the two-piece implants may cause a greater impact on bone levels, as well different crestal bone resorption patterns could have resulted from the effects of the subcrestal positioning of these various implant types. The subcrestal site in both implant types can result in more severe bone loss (47). Considering the limitations of this investigation (35), it is possible to determine that both implant designs produced good survival rates with a value of 100% for the transgingival group and 96.4% for PS implants group as well as comparable changes in bone level, clinical parameters, and patient-related outcomes 2 years after implant placement. Nevertheless, less marginal bone level alterations occurred before implant loading within the transgingival group (35).

Conical tapered PS implants were analyzed in the article of Ekstein et al(41) ,with a total of 112 implants , respectively 49 in maxilla and 63 in mandible. During the first day after implant insertion, the radiographic height of the mesial and distal bones was measured and 14 months after surgery to assess changes in marginal bone level over time. The findings of the current study showed that within the first year following the PS implants insertion, there were little changes in bone level. Clinically, the measured bone loss around the peri implant area was much lower than the 2 mm implant success criteria. After the first year, crestal bone loss was 0.67 ± 0.45mm, the survival rate was 100%. Compared to flat-to-flat connections, the internal conical implant-abutment connection with PS, analyzed in the article of Ekstein et al(41) is thought to be mechanically more robust and tight. At that intersection, bone loss at the crestal level is decreased by limiting micro-movements. Moreover, conical connections surrounding implants improve load distribution, protecting the marginal bone(41).

Same survival rate value as Ekstein et al(41) was found in case of DI implants during a 10 years follow-up in the study of Kadkhodazadeh et al (20), there was a 100% survival rate and a mean marginal bone loss of 0.29 ± 0.18 mm. In the research by Ghalen Golab et al (37), 533 DI implants were examined, and a 12-month follow-up revealed a 98% survival rate. But is important to take into account that a short follow-up was conducted in the research design (37). In the case of DI implants, micromovements can hinder osseointegration and abutment preparation throughout prosthetic phases can raise the temperature in the periimplant bone. So well planned prospective studies are required to evaluate these aspects. Unspecified factors, such as operator skills, patient conditions, and others that distort results, might have an impact on the study's findings (20). The results of Kadkhodazadeh et al(20) 10-year investigation indicate that DI narrow-diameter implants had a good 10-year implant survival rate and minimal marginal bone loss. In cases of thorough patient selection, these implants could reliably restore teeth in restricted areas.

Spinato et al (30) selected only a limited group of patients with a specific criteria such as non-smokers and posterior mandible location were included in this study's data collection. A total of 70 PS were placed and follow up of 1 year was conducted. According to the findings of this study, PS implants with internal hexagon inserted at the crestal level and replaced with short abutments (1 mm height) showed higher crestal bone loss than same types of implants but restored with long abutments (3 mm height), with no serious influences on peri-implant mucosal thickness. A survival rate of 97% with 4 implants failed was obtained (30).

More research is required to extrapolate these findings to a larger population and to various mouth regions. Almost the double number of PS implants were studied by Prati et al(40), so a total of 128 Ps implants were placed in maxilla and mandible. A follow up period of 4 years was conducted during which 2 PS implants failed , thus results in a survival rate value of 98.% and a success rate of 97.65%.The study's conclusions can be summed up as follows: with a minimally invasive flapless technique PS implants can be placed at tissue level (non-

submerged); only the timing of the implant placement from a previous extraction of the tooth appears to significantly affect the marginal bone level before loading and throughout the entire period of observation. When compared to delayed implants, early and immediate PS implant placement revealed less bone loss(40).

It is important to take into account that all the studies that included DI implants were done under ideal conditions and patients with good oral care. This type of implant is harder to clean than PS implant so the likelihood of infection and bone failure may be increased and, as well, may be more prone to fracture when excessive force is applied. For this reason, it would be more recommended the use of PS implant in case of single tooth missing.

6 CONCLUSIONS

The studies demonstrated that implant-prosthetic rehabilitation with Platform Switching implants or Direct implant restoration are a good option today because of the excellent success and survival rates. Mandibular implants appear to have a better prognosis than maxillary implants. It is important to consider the limits of this bibliographic review such as: different follow-up periods, different sample size followed into the studies, different criteria taken into consideration in each article regarding the success rate and different therapeutic approaches by the dentist and by the patient.

1. There was no significant difference in incidence implant failure so survival rate between Platform Switching and Direct implant restoration, both groups gave high survival rates in case of single tooth missing.

2. Regarding the success criteria, it was not possible to analyze it in the case of Direct implant restorations. However, in case of Platform Switching implants group, high success rates were founded. Further studies with standardized criteria are needed.

3. Platform Switching implants group implants were observed to have a substantial effect on marginal bone loss even if no big difference were found in Direct implant restoration group.

In both types of implant geometries more studies with longer-term results are needed.

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8 ANNEXES

8.1 Abbreviations

- IAI = Implant Abutment Interface
- PS = Platform Switching Implant
- DI = Direct Implant Restoration

8.2 Figures / Tables

- Figures

- Figure 1: Platform matching implant (A) , Platform Switching implant (B).The image underlines the size discrepancy as a result of the use of a narrow abutment with a wider implant platform (B) compared to a matching sizes between abutment and implant (A) (13).
- Figure 2: One piece implant composed by a bone and transmucosal component, the space between the reference point and the first thread is usually used as reference of bone level (19).
- Figure 3: Prisma flow chart.

- Tables

- Table 1: Data from 15 articles included in the study.