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Influence of implant shape and prosthetic platform on cervical bone resorption: A systematic review

Influência do formato do implante e da plataforma protética na reabsorção óssea cervical: Uma revisão sistemática

Influencia de la forma del implante y la plataforma protésica en la reabsorción ósea cervical: Una revisión sistemática

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Abstract

Purpose: The purpose of this systematic review was to critically evaluate the existing literature and answer the question, “Which implant format and prosthetic platform promotes the least cervical resorption?”. Material and method: SCOPUS, PubMed/Medline, Web of Science, EMBASE, Lilacs, and Google Scholar databases were searched in September 2023. Results: The database search resulted in 2850 articles. Of the 12 articles selected for full reading, 2 remained in this systematic review. There is a lack of information to form an opinion and to perform statistical analysis of the data, so descriptive analysis was performed. Conclusions: Based on the studies included in this systematic review, the implant shape influences primary stability and osseointegration, but it is not yet possible to relate it directly to POC. However, the type of prosthetic platform has a direct influence. In addition to the type of prosthetic platform used, the various characteristics related to the shape of the implant must be considered to maintain satisfactory bone levels.
Keywords: Cervical bone loss; Implant shape; Prosthetic platform; Dental implants.

Resumo

Objetivo: O objetivo desta revisão sistemática foi avaliar criticamente a literatura existente e responder à pergunta: "Qual formato de implante e plataforma protética promove a menor reabsorção cervical?". Material e método: Foram pesquisadas através das bases de dados SCOPUS, PubMed/Medline, Web of Science, EMBASE, Lilacs e Google Scholar em setembro de 2023. Resultados: A pesquisa nas bases de dados resultou em 2850 artigos. Dos 12 artigos selecionados para leitura integral, 2 permaneceram nesta revisão sistemática. Há falta de informação para formar uma opinião e para efetuar uma análise estatística dos dados, pelo que se procedeu a uma análise descritiva. Conclusões: Com base nos estudos incluídos nesta revisão sistemática, a forma do implante influencia a estabilidade primária e a osseointegração, mas ainda não é possível relacioná-la diretamente com o POC. No entanto, o tipo de plataforma protética tem uma influência direta. Para além do tipo de plataforma protética utilizada, as várias características relacionadas com a forma do implante devem ser consideradas para manter níveis ósseos satisfatórios.
Palavras-chave: Perda óssea cervical; Forma do implante; Plataforma protética; Implantes dentários.

Resumen

Propósito: El propósito de esta revisión sistemática fue evaluar críticamente la literatura existente y responder a la pregunta: "¿Qué formato de implante y plataforma protésica promueve la menor reabsorción cervical?". Material y método: Se realizaron búsquedas en las bases de datos SCOPUS, PubMed/Medline, Web of Science, EMBASE, Lilacs y Google Scholar en septiembre de 2023. Resultados: La búsqueda en las bases de datos dio como resultado 2850 artículos. De los 12 artículos seleccionados para la lectura completa, 2 permanecieron en esta revisión sistemática. Se carece de información para formarse una opinión y realizar un análisis estadístico de los datos, por lo que se realizó un análisis descriptivo. Conclusiones: Según los estudios incluidos en esta revisión sistemática, la forma del implante influye en la estabilidad primaria y en la osteointegración, pero aún no es posible relacionarlo directamente con el POC.

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Sin embargo, el tipo de plataforma protésica tiene una influencia directa. Además del tipo de plataforma protésica utilizada, deben tenerse en cuenta las diversas características relacionadas con la forma del implante para mantener unos niveles óseos satisfactorios.
Palabras clave: Pérdida ósea cervical; Forma del implante; Plataforma protésica; Implantes dentales.

1. Introduction

Oral rehabilitation with dental implants restores form and function by stabilizing prostheses in anodontic spaces and its success is recognized by the survival of these devices due to bone loss in the cervical region (Camarda, et al., 2021). The longevity of implants is assessed using radiographs, CBCT, and peri-implant probing (Gago-García, et al., 2021). Cervical bone loss is dependent on the biological response of the host and is influenced by systemic, anatomical, and functional conditions, installation time, adequate function, and occlusion (Juan-Montesinos, et al., 2022; Abrahamsson, et al., 2009; Aslam & Ahmed, 2015).

Marginal bone loss (MBL) can be up to 1.5 mm in the first year, and when excessive it compromises the position of the marginal gingiva, aesthetics, implant survival, and longevity (Camarda, et al., 2021; Fuda, et al., 2023; Juan-Montesinos, et al., 2022; Aslam & Ahmed, 2015; Annibali, et al., 2012; Atieh et al., 2010). When uncontrolled, the initial bone loss aggravates the contamination and associated with the lack of hygiene control, leads to peri-implantitis (RothameL, et al., 2022).

Different prosthetic platforms influence MBL, as the contact region between implant and bone has less protection against bacterial infections and is susceptible to the action of pro-inflammatory cells, which influences the quality of gingival tissue and bone stability (Fuda, et al., 2023). The highest incidence of this process is in the External Hexagon (EH) connection, which distributes occlusal forces heterogeneously, affects the metabolic process that results in bone loss, as well as allowing micromovements, loosening of the prosthetic component screw and fatigue fracture (Pera, et al., 2021; Juan-Montesinos, et al., 2022). These factors led to the development of the Internal Hexagon (IH) and Morse Cone (MC) platforms to reduce the disadvantages, complemented by modifications to the surgical technique, which increased the longevity of the rehabilitations.

IH has more homogeneous load distribution and less bacterial microleakage compared to EH, but it has worse prognosis in cases of full arch rehabilitation (Pera, et al., 2021). Bittencourt, et al., 2021, observed that MC connections have lower microgaps when compared to EH and IH, in addition to showing greater resistance to torque loss. As a result, there is a reduction in the formation of microleakage and less predisposition to peri-implantitis.

Among the development strategies for reducing MBL, the combination of altering prosthetic platforms with lower diameter prosthetic abutments and repositioning the cervical portion of the implant to the bone level has led to less peri-implant bone loss and better stress distribution, as seen in platform-switching (Lazzara & Porter, 2006; Fuda, et al. 2023), which brought biomechanical benefits by directing the stresses along the axis of the implant, away from the interface with the bone crest, and microbiological benefits by fixing the connective tissue to protect against microbial contamination and preserving the bone around the implant (Kowalski, et al., 2021; Gago-García, et al., 2021).

Regarding the shape of the implant, which aims to provide the initial mechanical stability necessary for osseointegration and optimize load distribution (Oliveira, et al., 2020), considerations of the designs, dimensions, thread designs, and surface texture determine the durability of the implant and the distribution of tensions along the implant body. These factors can facilitate bone growth and viability during surgery and favor the reduction of deleterious tensions on the bone during the function of the stomatognathic system, which favors the permanence of these devices (Heimes, et al., 2023).

It is important to investigate how it is clear in the literature that the prosthetic platform and the shape of the implant influence cervical bone preservation and consequent implant durability. It is known that the literature in this area is vast, as is the rapid development of new products by the industry.

Therefore, to discuss these factors clearly and provide conditions for selecting different devices to take advantage of their advantages and disadvantages, the purpose of this systematic review was to critically evaluate the existing literature and answer the question "Which implant format and prosthetic platform promotes the least cervical resorption?”.

2. Methodology

2.1 Elaboration

This systematic review followed the guidelines of the Preferred Reporting Items for Systematic Review and Meta-Analyses Protocols) and the PRISMA checklist (PRISMA, 2020) (Page, et al., 2021). The study sought to answer the following question: Which implant shape and which prosthetic platform promotes less cervical bone resorption? ".

The population, intervention, comparison, results, and study design (PICOS) for this systematic review are defined in Table 1. Item C of the PICOS included randomized and non-randomized clinical trials.

2.2 Inclusion criteria

Studies related to the influence of implant shape and prosthetic implant platform on cervical bone resorption. Clinical studies randomized or not and published in journals available in the databases used.

2.3 Exclusion criteria

Animal studies, studies that did not define radiographic monitoring as an evaluation criterion for marginal bone resorption, overdentures, partial prostheses on implants, studies based on finite element analysis, ex vivo studies, in vitro studies, reviews, book chapters, and authors' opinions were also excluded.

2.4 Databases and search strategy

The searches were carried out in the following databases: PubMed/Medline, Embase, Lilacs, Web of Science, Scopus and Google Scholar. The literature search was carried out in September 2023 and included all studies published up to 2023 in periods indexed in the Journal Citation Reports (JCR).

The search was carried out using the following MESH (Medical Subject Headings): (("bone loss" OR "cervical bone loss" OR "bone reabsorption") AND ("prosthetic platform" OR "prosthetic" OR "platform") AND ("dental prosthesis" OR "prosthesis") AND ("macrodesign" OR "design" OR "macrogeometry" OR "dental implant shape")).

Table 1 – Picos.

PICOS	**DESCRIPTION**
PARTICIPANTS	Titanium implants
INTERVENTIONS	Implant Shape and Prosthetic Platform
COMPARISONS	Comparative group/ Intervention group
OUTCOMES	Marginal bone loss
STUDY DESIGNS	Clinical studies

PICOS, participants, interventions, comparisons, outcomes, study designs. Source: Authors.

2.5 Study selection and data extraction

The article selection process was carried out in two stages. In the first step, reviewer V.M.S. evaluated the title and abstract of the studies resulting from the initial search strategy were in the Rayyan web application according to the eligibility criteria, to select the articles to be read in full. In the second step, V.M.S. independently assessed the articles selected for full reading according to the eligibility criteria, and discarding studies that did not meet the inclusion criteria. Doubts regarding the inclusion or not of the article were resolved.

The selected studies were fully evaluated, and the data tabulation was performed in an Excel spreadsheet according to the criteria (a) Author, year of publication; (b) Aim of the study; (c) Analysis Method; (d) Implant shape; (e) Connection platform; (f) Trade name and manufacturer; (g) Results (Table 2).

2.6 Analysis of the risk of bias

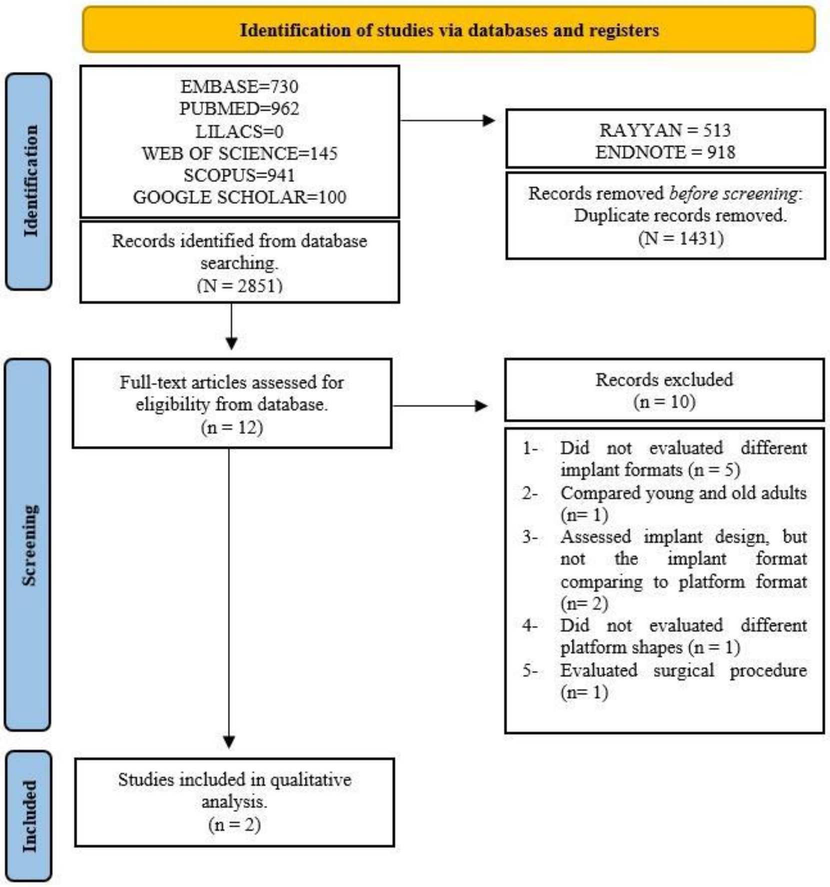
The quality and risk of bias of the included studies were assessed using The Cochrane RoB 2.0 tool. Each study was classified as low risk, possible risk, or high risk of bias.

3. Results

3.1 Search and selections

A total of 2,850 publications were identified through 6 databases. Initially, 1,431 studies were excluded because they were duplicates. After analyzing the title and reading the available abstract, 12 articles remained for full reading. When the eligibility criteria were met, 2 studies were eligible for the qualitative analysis (Table 2). The selection process is shown in Figure 1 (flowchart), and the reasons for exclusion are in Table 3.

Figure 1 – Flowchart of literature search and selection criteria.



Source: Authors.

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3.2 Risk of bias

The studies with 80% of the responses marked as low risk of bias were classified as low risk of bias. Studies with 79–50% of responses as low risk were classified as moderate risk, and below 50% were considered high risk of bias. Thus, the 2 studies were classified as having a low risk of bias (Figure 2).

Figure 2 - Risk of bias of the included studies by The Cochrane Rob Tool 2.0.

Note: General analysis of the risk of bias of the included articles. Source: Authors.

3.3 Characteristics of the studies

The studies included in this review were published between 2012 and 2013. All the included articles were clinical randomized trials. The two studies aimed to evaluate the bone loss around different implant formats and platforms by radiographic measurements. One of the two studies did not use a cylindrical implant to compare with a tapered one, but the study was included because the shape characteristics are similar to cylindrical implants.

Table 2 - Data extraction.

GULTEKIN et al., 2013	POZZI et al., 2012	**Author, Year**
To determine the possible differences in peri-implant hard and soft tissue integrity around 2 implants and different platform connections	To compare clinical and radiological outcomes of two implant designs with different prosthetic interfaces and neck configurations in a randomized, controlled, split-mouth clinical trial.	**Aim of the study**
Radiographic measurements to determine the total change in crestal bone levels	Radiographic measurements by periapical radiographs at time points: implant placement (baseline), abutment connection (8 weeks), implant loading (4 months), and 1 year in function (16 months)	**Analysis Method**
Conical (Nobel Active, Nobel Biocare) and Conical (Nobel Replace Tapered Groovy, Nobel Biocare)	Test Group (Conical) and Control Group (Cylindric)	**Implant shape**
Control group – Matched platform abutment (Flat-to-flat) and Test Group – (Platform Switching)	Test group - Internal-hexagon with conical prosthetic interface (platform switching) and Control group external-hexagon connection (flat-to-flat) connection	**Connection Platform**
Test (Nobel Active, Nobel Biocare) and Control (Nobel Replace Tapered Groovy, Nobel Biocare)	Test (Nobel Active, Nobel Biocare AB, Goteborg, Sweden) and control group (Nobel-Speedy Groovy, Nobel Biocare AB)	**Trade name and manufacturer**
The mean values for crestal bone loss after 3 months of submerged healing were 0.22 ± 0.11 mm for the test implants and 0.24 ± 0.14 mm for the control implants (Student t-test; P > .05). However, both groups showed increased bone loss at the 1-year follow-up examination (0.35 ± 0.13 mm and 0.83 ± 0.16 mm, for test and control groups, respectively). The differences within each group and between groups were statistically significant (paired-sample t-test; P < .01) (Fig 3). Regarding site-specific characteristics of peri-implant bone resorption, progressive bone loss around implants in both groups was less pronounced at lingual sites than at buccal sites at 3 and 15 months compared to baseline bone levels (both P < .01; Table 1).	The mean bone crest level was not statistically significantly different at the moment of implant placement (p = .061) and at the abutment connection (p = .011), after the prosthesis delivery after 4 months (p = .000), and 1 year after loading (p = .000) showing statistically difference between the investigated groups. Both groups gradually lost a slight amount of marginal periimplant bone, but the control group showed worse results during the entire investigated period.	**Results**

Note: Characteristics of included studies evaluating the influence of implant shape and prosthetic platform in marginal bone loss. Source: Authors.

Table 3 - Articles excluded after the selection.

Author, year	Exclusion reason
BRYANT et al., 2003	The study aimed to compare young and old adults' prognostic.
GLIBERT et al., 2017	The study aimed to assess micro threaded design and internal abutment connection, not implant format and platform shape in cervical bone loss
GOTHBERG et al., 2018	The study assessed different platform shapes and designs, but the same implant format
MERTENS et al., 2012	The study did not include different platform shapes
MOBERG et al., 2001	This study aimed to evaluate surgical procedure and not the implant format
PESSOA et al., 2016	The study assessed different platform shapes but the same implant format
VAN DE VELDE et al., 2009	The study is concerned with assessing the implant design
WINDAEL et al., 2017	The study just assessed the same implant format
POZZI et al., 2014	The study assessed different platform shapes and designs, but the same implant format.
GULTEKIN et al., 2013	The study assessed different platform shapes and designs, but the same implant format.

Note: Articles that were excluded after the second selection stage and the reasons for that. Source: Authors.

4. Discussion

This systematic review aimed to determine whether there was clarity in the literature about the relationship between implant shape and osseointegration and prosthetic durability, and the most suitable prosthetic platform for reducing POC and implant longevity. The relationship between implant shape and prosthetic platform is widely presented in the literature, confirmed by 2851 articles found in the initial search by combining ((“bone loss” OR “cervical bone loss” OR “bone reabsorption”) AND (“prosthetic platform” OR “prosthetic” OR “platform”) AND (“dental prosthesis” OR “prosthesis”) AND (“macrodesign” OR “design” OR “macrogeometry” OR “dental implant shape”)) in the following databases: Pubmed, Embase, LILACS, Scopus, Web of Science, Google Scholar. However, when we searched for answers to the association between geometric factors and prosthetic platforms through the eligibility criteria, only 2 articles in the literature were included due to the approximate relationship between the shape of the implant and the type of prosthetic platform with the marginal bone loss.

Pozzi, et al., 2012, compared two types of implants in their study. The control group consisted of a conical implant, switching platform with internal coupling of 12o conical shape with hexagonal interlocking (NobelActive, Nobel Biocare AB, Goteborg, Sweden), the test group consisted of a cylindrical implant with a straight neck and flat implant-abutment interface with external hexagonal connection. (NobelSpeedy Groovy, Nobel Biocare AB), both with the same surface treatment, installation torque (35 Ncm), final restoration delivery period (after 4 months), and monitoring frequency (3 months). The cervical bone level (CBL) was not different at implant installation ($p = 0.061$) and abutment connection ($p = 0.011$). On the other hand, at the time of prosthesis delivery ($p = 0.000$) and 1 year after loading ($p = 0.000$), there was a significant difference between the groups investigated. There was gradual loss of peri-implant marginal bone in both groups, but the control showed better radiological results throughout the period investigated. One limitation is the intrinsic difficulty in comparing completely different implant models and drawing conclusions regarding POC. Thus, the results suggest that POC is the result of changes to the prosthetic interface and the configuration of the implant neck.

Gultekin, et al., 2013, compared two types of implants with the same surface structure, different characteristics and prosthetic platforms. The control group had a structure similar to the cylindrical one, but with a conical apex and flat-to-flat platform. The test group had a conical structure, a switching platform and conical connections. The average value for POC 3 months after installation in the test group was 0.22±0.11 mm, and 0.24±0.14 mm for the control group. However, after a 1-year follow-up, 0.35±0.13 mm and 0.83±0.16 mm were noted for the respective groups. Although both groups did not show bone remodeling in the period prior to loading, lower POC was observed in the test group. Thus, they suggest that POC is related to the microgaps present at the implant-abutment interface, the submission of loads, and the absence of a favorable region for re-establishing the biological distance.

Since the two articles found in the literature, which met the eligibility criteria, are not sufficient to form an opinion on the influence of the prosthetic platform and the type of implant, other studies found in the literature are important to cite to explain the need for studies on this subject.

Considering the concern to avoid MBL, Branemark in 1977 justified his two-stage surgical technique through complete osseointegration, but its invasiveness and post-surgical complications evolved it to a single-stage and closed technique (Bedrossian, 2019; Annibali, et al., 2012). Maier, 2016, showed that the flapless technique is faster, promotes greater tissue preservation, lower POC and postoperative pain, and minimal disturbance of the vascularization of the peri-implant tissue. Implant vascularization occurs mainly through the periosteum and can be compromised by invasive techniques that generate potential POC (Naeini, et al., 2023; Vlahovic, et al., 2013; Badge, et al., 2023).

The limitation of our study was the shortage of studies that were up to the inclusion criteria. Only one article compared cylindrical to conical implants and related to MBL, and another study compared two conical implants and related to MBL, but one of them has shape characteristics that are close to the cylindrical, and for that reason, the study was included. There are two types of shape (Cahyaningtyas, et al., 2023), conical implants use lateral and vertical pressure to achieve stability, while cylindrical implants rely on static friction at the base (Heimes, et al., 2023). Tapered implants facilitate clinical practice by reducing bone drilling steps, generating less surgical trauma, less bone resorption in the primary stages and accelerated bone remodeling under adequate insertion torque, better distribution of occlusal loads, less susceptibility to buccal bone drilling, and achieving higher insertion torque (Heimes, et al., 2023; Kreve, et al., 2022). Due to lower primary stability, less resistance to vertical movements, and shear stresses, cylindrical implants are favorable under delayed loading (Vandamme, et al., 2008). In a systematic review conducted by Alshehri & Alshehri, F. 2016, implant shape did not differ in implant survival in the posterior maxilla (Cahyaningtyas, et al., 2023). Sargolzaie, et al., 2017, showed that cylindrical implants did not have higher MBL after 6 months. The results of PARK, et al., 2021, corroborate this. However, in the study eligible for inclusion in this review, Pozzi, et al., 2012, found lower MBL in conical implants with a switching platform compared to flat-to-flat cylindrical implants with an EH-type platform.

Primary stability can be enhanced through high insertion torques, but as a consequence, there is an increased inflammatory response and tensions in the surrounding bone, which can result in MBL (Gehrke, et al., 2022; Vandeweghe, et al., 2012). The mechanical and behavioral factors of stress (amplitude, direction, rate, and frequency) affect bone remodeling, particularly in the neck region (Cehreli et al., 2004). Thus, cylindrical implants may require a higher insertion torque to achieve primary stability, and if exceeded by 50 Ncm may potentiate MBL (Nandini, et al., 2022; Stoilov, et al., 2023). Sargolzaie, et al., 2017, demonstrated that cylindrical implants showed a slight increase in MBL compared to conical implants, but not in a statistically significant way.

Bone resorption occurs to ensure that the biological width is re-established. The difference between diameters in the switching platform results in a circular step that allows the horizontal expansion of the biological width, to protect osseointegration and preserve the cervical bone level at the level of the implant-abutment junction (Annibali, et al., 2012; Askar, et al., 2020; Cahyaningtyas, et al., 2023). The presence of thick insertion tissue is related to reduced MBL, but in the switching technique, the thickness of the oral tissues is not relevant for maintaining the cervical bone level (Askar, et al., 2020; Vervaeke, et al., 2014; Suarez-Lopez Del Amo, et al., 2016).

Regarding the differences in the prosthetic platform, Pozzi, et al., 2012, suggest that favorable results for MBL are related to the switching platform, and its ability to favor the reestablishment of biological distance through a horizontal process, and its ability to distance the inflammation process existing at the implant-abutment interface from the alveolar bone crest. The results presented by Guerra et al., 2014, when evaluating MBL between platform switching and matching corroborate Pozzi's assertion that the platform switching concept could have a positive impact on early bone remodeling. Herrero-climent, et al., 2020, suggest that when looking for favorable aesthetics, due to their relationship with bone preservation, opt for the installation of platform-switch implants at bone level.

This systematic review sought to highlight important factors for selecting dental implants that can positively influence the reduction of MBL. It should be noted that in addition to rehabilitation planning, local, systemic, and social aspects are involved in clinical success. Local aspects include occlusal dynamics and characteristics related to the implant structure. Biological aspects include systemic health, the patient's age, the quality of bone available, the surgical procedure, immediate loading of the implant, and poor osseointegration process. Finally, the social aspects involve oral hygiene habits (Kowalski, et al., 2021; Fuda, et al., 2023; Annibali, et al., 2012).

5. Final Considerations

Based on the studies included in this systematic review, the shape of the implant influences primary stability and osseointegration, but it is not yet possible to relate it directly to POC. However, the type of prosthetic platform used has a direct influence. In this sense, in addition to the type of prosthetic platform used, the various characteristics related to the shape of the implant (type of thread, thread pitch, and thread depth) must be considered to maintain satisfactory bone levels. Furthermore, when considering the different formats available on the market, it is up to the dental surgeon to indicate the option that best suits the demands of the case.

With the present systematic review, the answer to the question is only possible to provided that further research is carried out to understand the implant shape and prosthetic platform in the marginal bone loss activity to provide implant survival and longevity.

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