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Review Article

Morse taper dental implants and platform switching: The new paradigm in oral implantology

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ABSTRACT

The aim of this study was to conduct a literature review on the potential benefits with the use of Morse taper dental implant connections associated with small diameter platform switching abutments. A Medline bibliographical search (from 1961 to 2014) was carried out. The following search items were explored: "Bone loss and platform switching," "bone loss and implant-abutment joint," "bone resorption and platform switching," "bone resorption and implant-abutment joint," "Morse taper and platform switching." "Morse taper and implant-abutment joint," Morse taper and bone resorption," "crestal bone remodeling and implant-abutment joint," "crestal bone remodeling and platform switching." The selection criteria used for the article were: Meta-analysis; randomized controlled trials; prospective cohort studies; as well as reviews written in English, Portuguese, or Spanish languages. Within the 287 studies identified, 81 relevant and recent studies were selected. Results indicated a reduced occurrence of peri-implantitis and bone loss at the abutment/implant level associated with Morse taper implants and a reduced-diameter platform switching abutment. Extrapolation of data from previous studies indicates that Morse taper connections associated with platform switching have shown less inflammation and possible bone loss with the peri-implant soft tissues. However, more long-term studies are needed to confirm these trends.

Key words: Bone loss, crestal bone remodeling, implant-abutment connection, Morse taper, platform switch, platform switching

INTRODUCTION

Dental implants have achieved long-term success due to the osseointegration of highly biocompatible titanium integrating to the surrounding bone.[1,2] Following the establishment of osseointegration, the implant system depends on the mechanical and chemical stability of the contacting metal joints, which must sustain proper torque originated from the friction between contacting surfaces. Through the development of novel techniques on surface treatment, as well as enhanced implant design, modern implants have improved the prognosis of the long-term osseointegration and performance of dental implants.[1-6]

In regards to implant dentistry, criteria for a sustainable, healthy soft tissue outline is a prosthesis that provides mechanical strength and remains esthetically pleasing.[6-8] This aesthetic outcome with dental implants

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is similar to conventional dental prosthetic restorations. However, many edentulous spaces have esthetic and mechanical limitations linked to poor bone quality and the anatomical remodeling of the remaining hard and soft tissues. Due to limitations in bone augmentation procedures and implant screw-retained prostheses associated with dental implants, often the ideal esthetic position is not a viable option.[6-9]

Regarding studies supporting long-term success rates of implants, the main concern is surprisingly not related to osseointegration. Rather, the focus is on the maintenance of hard and soft tissues over the lifetime of the dental implant system. Considering soft tissue maintenance and implants, the presence or absence of gingival papillae is one of the main concerns. The loss of the interproximal gingival papillae may lead to food accumulation, esthetic deficiencies and phonetic problems.[8-10]

Regarding implant dentistry, the soft and hard tissue biological dimensions are initially recorded based upon the timing of the initial load. This difference in record keeping is observed on comparing two-stage dental implant cases when biological dimensions are defined after the initial submerged healing period, versus nonsubmerged/single-stage dental implants, where measurements are recorded at the time of implant placement.[8-11]

Considering the novelty in technology on dental implant joints, Jokstad *et al*. noted the development of internal connections showing improved results regarding esthetic outcomes and mechanical stability.[12] Currently, common examples of internal implant-abutment connection designs are the internal hexagonal and the Morse taper connection. A unique design feature of the Morse taper implant-abutment connection is an internal joint design between two conical structures [Figure 1]. This connection was developed by Stephen A. Morse, in 1864, and since has been globally used to connect drilling machines to a removable rotating drill piece. In implant dentistry, a conical "male" abutment is tightened into a "female" conical implant design. This internally tapered design creates significant friction via the high propensity of parallelism between the two structures within the joint space. The Morse taper angle is determined according to the mechanical properties of each material. For instance, titanium-based structures have an ideal relationship between contacting surface angles and coefficient of friction.[12,13]

The internal Morse taper implant-abutment design aligns the microgap sizes to be further separated from the marginal bone. In addition, this internally stable design allows for a narrower abutment platform abutment design that can be additionally combined with platform switching [Figure 2]. The platform switching abutment design has shown clinically to reduce marginal bone loss and provide additional space for soft tissue development and maintenance over longer follow-up studies.[14-24]

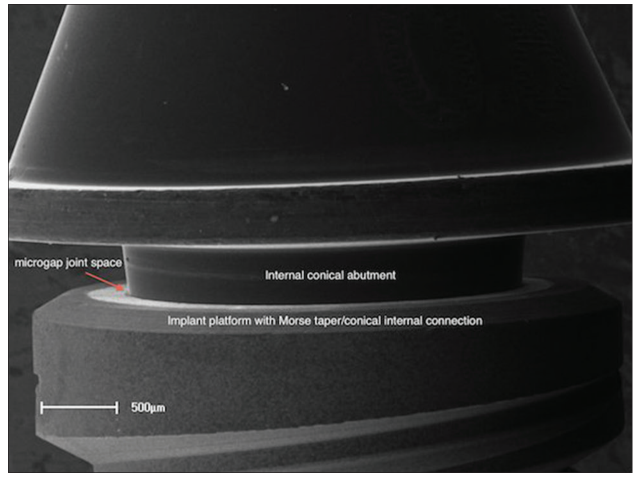

Figure 1: Scanning electron microscopy of Morse taper implant-abutment conical connection design without platform switching

Thus, the main purpose of this study was to review current evidence on the benefits of Morse taper dental implant joints associated with platform switching. It was hypothesized that Morse taper connections involving platform switching would increase the maintenance of peri-implant bone and soft tissues. Thus, likely maintaining the soft tissue profile, reducing the incidence of bone-loss, and ultimately the onset and rate of marginal peri-implantitis associated with the implant-abutment platform.

MATERIALS AND METHODS

A Medline bibliographical search (from 1961 to 2014) was carried out. The following search items were explored: "Bone loss and platform switching," "bone loss and implant-abutment joint," "bone resorption and platform switching," "bone resorption and implant-abutment joint," "Morse taper and platform switching," "Morse taper and implant-abutment joint," "Morse taper and bone resorption," "crestal bone remodeling and implant-abutment joint," "crestal bone remodeling and platform switching."

The eligibility inclusion criteria used for article search were: Meta-analysis; randomized controlled trials; prospective cohort studies; as well as articles and reviews written in English, Portuguese or Spanish

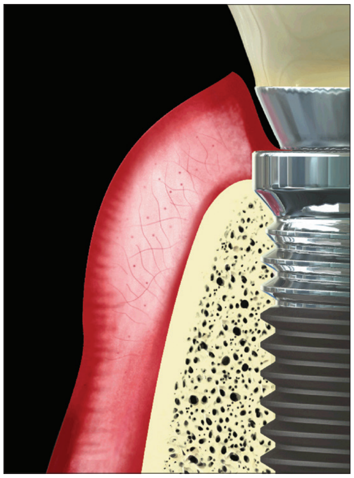

Figure 2: Schematics of a platform switching system and surrounding hard and soft tissue profile

languages. The literature selection accepted the following tests: Microbiological assays; physical and mechanical characterization; biomechanics by analytical finite element tests or photoelastic spectrometry; and clinical trials performed in animals or humans under radiographic evaluation.

RESULTS

On the 287 studies identified, 81 relevant and recent studies were selected. The reviewed studies noted a significant clinical outcome with Morse taper implants associated with smaller diameter platform switching abutments. However, some parameters of the scientific inquiry tested may not have direct relevance to the clinical application and long-term treatment outcomes found in implant dentistry.

Within the scientific review, the noted benefits on Morse taper implants and platform switching abutment are listed as follows:

- Morse taper design showed a marked decrease in the microgap size found within the abutment-implant joint, thus reducing biofilm accumulation;[14-28]
- Morse taper implants revealed less peri-implantitis when placed supra-crestally;[2,21,24,29-53]
- Reduced resorption of crestal bone;[2,30,36-59]
- The biological width formation takes place apical and laterally around the abutment and the implant's horizontal platform;[8,9,11,30,37,40-42,44,54-67]
- The smaller abutment diameter in proportion to the implant diameter, naturally augments for increased thickness of the connective soft tissue around the abutment;[40-42,56,57]
- Torque stability and maintenance of the loaded contacting surface is high due to the biconical Morse system established between the implant and the intermediate screw,;[2,13,68-80]
- The Morse tapered machined connection design was associated with decreased micro-movements during distribution of occlusal forces on the implant;[16,68-70,72-74,76,79,81]
- Morse taper implant-abutment design eliminates the need for additional screw retained connections associated with other implant-abutment designs.[79,82-84]

One should accentuate the fact in all the mentioned studies, the distances between implants, of 1, 2 or 3 mm did not show statistically significant differences concerning the bone behavior.[28,52-54] Such results support the assumptions the researchers believe to be responsible for the bone behavior around Morse taper implants and abutments incorporating a "platform switch" model.

DISCUSSION

Since clinical dentistry is multifactorial, the results gathered in this study showed a broad range of topics and relevance to the essence of the current article topic. From the articles reviewed, the most common noted concepts throughout the articles relating Morse taper implants and platform switching were marginal bone loss, maintenance of soft tissue anatomical dimensions, implant-abutment microgaps, and aesthetics.

Peri-implant management

The biological periodontal morphology and anatomy around the tooth is frequently mentioned in the literature. In 1961, Gargiulo, Wents, and Orban, reported the mean length values of the gingival sulcus to gingival crest at approximately 0.69 mm, junctional epithelium at 0.97 mm and the connective tissue area at 1.04 mm.[60] Subsequently, Vacek *et al*., carried out an *in vivo* study confirming the accuracy of the periodontal dimensions surrounding natural dentition with similar mean values of connective tissue (0.77 mm) and the junction epithelium (1.14 mm).[61] Berglundh *et al*. compared the gingival composition on natural teeth and the contacting mucosa with dental implants. Both tissues showed similar microscopic features such as: A continuous keratinized epithelium linked to the junctional epithelium that comprised a length of 2 mm; the epithelium was separated from the alveolar bone by a connective tissue zone >1 mm.[62,63]

Cochran *et al*., evaluated the influence of loading on the presence of biological widths surrounding nonsubmerged implants and concluded that the dimensions and relationships of mucous membrane/implant are similar to the dento-gingival tissues.[65] On the tissues, the measurements were similar both on loading as well as the absence of mechanical conditions. These tissue arrangements naturally imply hard tissue remodeling around the implant. After second-stage implant exposure and abutment placement, an implant-abutment connection creates the possibility of a bone resorption occurrence of approximately 1.5–2 mm in the apical direction.[65]

Aside from tissue organization, a biological reason might exist for this phenomenon: If chronic irritants, like bacteria, reach the implant connection area, or if the connections are removed after the initial healing, bone may resorb, creating a gap, and exposing the affected area.[21-24]

Other additional factors have shown to affect bone loss as well, such as: Surgical trauma, occlusal overload, peri-implantitis, micro-movements, the biological width, and implant anatomy on the crestal region.[29-33,45-47,68-70,74-78] Tarnow *et al*. previously reported, through the histological result, similar bone response on sub gingival dental preparations of prosthetic crowns, which disrupted the attachment apparatus on natural teeth.[54,67]

This bone loss, occurring around the implants may interfere with the aesthetic results after accomplishment of the restorative treatment, since the bone crest height may influence the presence or absence of the interdental papilla. The vertical distance between the base of the interproximal contact point of the natural dentition to the bone crest is an important factor on bone preservation and consequently, on the presence of a sufficient interdental papilla.[9,30,54-57,63] When interdental sites were assessed, it was verified that when the distance occurred around 5.0 mm or less, the interdental papilla was present in 98% of the cases. However, there was a papilla present in 56% of the cases at interdental papilla at 6.0 mm and in 27% at 7.0 mm or more.[54,67]

In a study by Tarnow *et al*., radiographs were evaluated from 36 patients, which presented two adjacent implants. The lateral bone loss was measured from the bone crest to the implant surface.[54] This data were subdivided into two groups, based on the distance between the implants. The results showed that less crestal bone loss around implants with a distance equal or >3 mm, than around implants with an inter-implant distance <3 mm. The data revealed that besides the vertical components usually studied, there is an influence relating lateral proximity of adjacent implants on the bone loss of the adjacent implant. The increase in the bone crest loss results in an increase of the distance between the contact point from adjacent crowns and the bone crest. This observation can affect the clinical outcome on whether or not significant interdental papilla is present between two neighboring implants. Another study was done to assess the influence of both vertical and horizontal distances concerning the incidence of the interproximal papillae between adjacent implants and between tooth and implant. The authors concluded that when the distance between implants was < 3 mm, there was an absence of a papilla, regardless of the vertical distance. It was, then, described that the proper distance between implants or between tooth/implant varies from 3 to 4 mm.[54,67]

Platform switching

Within the last decade, maintaining the periodontium soft tissue surrounding the dental implant via smaller abutment diameter on platform switching has gradually gained recognition beyond a novel paradigm. Considering geometry of the dental implant system, the concept of a smaller abutment diameter to maintain and enhance the peri-implant soft tissues has continued to show evidence of clinical success.

Atieh *et al*. (2010) conducted a systematic review on the clinical relevance of platform switching and preservation of peri-implant crest bone levels.[51] Ten clinical studies reported a statistically significant influence of the platform switching on the maintenance of marginal bone levels. Annibali *et al*. (2012) conducted a similar systematic review on platform switching versus conventionally restored implants or peri-implant marginal bone loss.[52] Ten randomized controlled trials were selected for review dated from 2007 to 2011. Six of the ten clinical studies noted a significant difference of reduced marginal bone loss around platform switching implant-abutment group versus a traditional design. Subgroup analyses show less marginal bone loss as the platform switching mismatch increased. Subsequently, the inward shifting of the implant-abutment joint interface likely reduced microbial leakage and micromovements that have been additionally associated with marginal bone loss.

Microgap and Morse taper connections

Noted at the implant-abutment joint, inflammatory agents and their chemotactic stimulus of neutrophils and other inflammatory cells infiltrate the surrounding localized tissues promoting long-term osteoclastic bone loss within the alveolar bone.[11]

Previous studies conducted *in vitro* tests using different sized species of bacteria to evaluate inside-outside migration into different type of implant-abutment connections (screwed implant-abutment, cemented implant-abutment and internal conical connections). The internal connection area of different types of implants was inoculated with bacteria suspensions. Following manufacturer's instructions for torque values, abutments were connected to implants either through screw or cementation and submerged in a sterile nutrient solution test for different times. The screw retained implant abutment showed a high frequency of microbial penetration versus the cement and conical connection. The lower penetration of microbial cells into Morse taper connections occur due to a higher contacting area between biconical abutment and implant connection surfaces.[17-22]

Bone remodeling and implants

The bone crest around the implant fixture may act as lever fulcrum point when a flexural force is applied.[39] Concerning overloads, photo-spectrometric and finite element analysis has been used to evaluate the stress distribution around implants and the surrounding bone. [9,16,59,68-70]

The bone's mechanical integrity is the result from its remodeling.[31,36,38,43,53] Osteocytes play an important role on bone remodeling by influence of chemical mediators that are released within the interstitial fluid under external loads.[2,41,53] Osteoblasts are recruited while osteoclasts are inhibited. In comparison with cortical bone, a higher rate of osteocytes has been associated with cancellous bone.[2,41,53] That suggests a more favorable peri-implant bone-remodeling prognosis to stabilizing mechanical stimuli and external injuries.[7,38,40,44,46,50,52] An additional advantage in sustaining bone levels is optimizing and facilitating the maintenance of the soft tissues surrounding the implant, especially those which surround the cervical third of the dental implant.[11,22,34,37,40,41,44,62]

The bone tissue around the implants continues a natural process of remodeling during the timing of implant placement and the accomplishment of the prosthetic treatment.[7,43] Observations on bone remodeling may be associated with occlusal force stimulation and the distance between adjacent implants.[7,43,45,65] Additionally, the magnitude and the direction of occlusal force can be altered based upon the presence of prosthetic connections and the occlusal load.[7,65,70]

CONCLUSIONS

A majority of the scientific literature noted in the article analyzed studies using *in vitro*, and animal-based *in vivo* assays. Many of the studies analyzed in this article lacked long-term patient clinical testing and follow-up data. These specific limitations found *in vitro* testing and animal-based studies likely do not mimic all of the oral and systemic factors associated with the human oral environment. The current longitudinal clinical studies do not provide significant long-term evidence of the benefits of Morse taper implants that has been highlighted with *in vitro* laboratory studies.

Despite these limitations, the Morse taper implant system with platform switching provides a more effective relationship between the implant and intermediary abutment for prolonged healing and health within the surrounding hard and soft tissues. The relevant studies reviewed noted that of the implant-abutment systems currently on the market, the Morse taper system with the use of a smaller abutment diameter has the following advantages: Preserves more of the peri-implant bone, stabilizes more of the soft tissues, reduces the microgap size found in the abutment-implant connection, and proper geometry for narrower mesio-distal edentulous spaces.

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Conflicts of interest

There are no conflicts of interest.

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