WJCC World Journal of Clinical Cases

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DOI: 10.12998/wjcc.v3.i1.65

World J Clin Cases 2015 January 16; 3(1): 65-76
ISSN 2307-8960 (online)

ORIGINAL ARTICLE

Retrospective Study

Posterior partially edentulous jaws, planning a rehabilitation with dental implants

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Ethics approval: None to declare.
Informed consent: None to declare.
Conflict-of-interest: The authors declare that they have no conflict of interest.
Data sharing: Technical appendix, statistical code, and dataset available from the corresponding author at goiato@foa.unesp.br. Participants gave informed consent for data sharing. No additional data are available.

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Received: June 19, 2014
Peer-review started: June 21, 2014
First decision: July 10, 2014
Revised: November 26, 2014
Accepted: December 3, 2014
Article in press: December 23, 2014
Published online: January 16, 2015

Abstract

AIM: To discuss important characteristics of the use of dental implants in posterior quadrants and the rehabilitation planning.

METHODS: An electronic search of English articles was conducted on MEDLINE (PubMed) from 1990 up to the period of March 2014. The key terms were dental implants and posterior jaws, dental implants/treatment planning and posterior maxilla, and dental implants/treatment planning and posterior mandible. No exclusion criteria were used for the initial search. Clinical trials, randomized and non randomized studies, classical and comparative studies, multicenter studies, *in vitro* and *in vivo* studies, case reports, longitudinal studies and reviews of the literature were included in this review.

RESULTS: One hundred and fifty-two articles met the inclusion criteria of treatment planning of dental implants in posterior jaw and were read in their entirety. The selected articles were categorized with respect to their context on space for restoration, anatomic considerations (bone quantity and density), radiographic techniques, implant selection (number, position, diameter and surface), tilted and pterygoid implants, short implants, occlusal considerations, and success rates of implants placed in the posterior region. The results derived from the review process were described under several different topic headings to give readers a clear overview of the literature. In general, it was observed that the use of dental implants in posterior region requires a careful treatment plan. It is important that the practitioner has knowledge about the theme to evaluate the treatment parameters.

CONCLUSION: The use of implants to restore the posterior arch presents many challenges and requires a detailed treatment planning.

Key words: Dental implants; Mandible; Maxilla; Edentulous jaw; Treatment

Core tip: The treatment plan for rehabilitation with dental implants in posterior quadrants of edentulous jaws must be meticulous. The professional must cautiously evaluate the treatment parameters to guarantee predictable and long-term restorations. The treatment plan includes detailed analysis of space for restoration, bone quantity and density, radiographic techniques, selection of number, diameter, and length of the implants, and occlusion.

Monteiro DR, Silva EVF, Pellizzer EP, Magro Filho O, Goiato MC. Posterior partially edentulous jaws, planning a rehabilitation with dental implants. *World J Clin Cases* 2015; 3(1): 65-76 Available from: URL: http://www.wjgnet.com/2307-8960/full/v3/i1/65.htm DOI: http://dx.doi.org/10.12998/wjcc.v3.i1.65

INTRODUCTION

Implant-borne rehabilitation is a good option of treatment for patients with partial edentulism[1-3]. The validity of osseointegrated dental implants for the rehabilitation of posterior partially edentulous jaw had been related in the literature by several studies[4-7]. These rehabilitations offers substantial benefits when compared with removable partial dentures: improved occlusion and support, simplification of the prosthesis, less invasive restorative procedures, bone maintenance and, improvement in oral health[8,9].

However, to obtain excellent results in rehabilitations with dental implants meticulous attention must be paid to details[10]. In addition, the posterior quadrants of the mouth are challenging for rehabilitation with dental implants[6,11,12] due to their anatomical and occlusal features[6,9]. Thus, this article aimed to discuss important characteristics of the use of dental implants in posterior quadrants and the rehabilitation planning.

MATERIALS AND METHODS

An electronic search of English articles was conducted on MEDLINE (PubMed) from 1990 up to the period of March 2014. The Key terms were dental implants and posterior jaws, dental implants/treatment planning and posterior maxilla, and dental implants/treatment planning and posterior mandible. No exclusion criteria were used for the initial search. Titles and abstracts of the screened articles were reviewed and the full text was assessed for an appropriate analysis. Then, the articles were analyzed through inclusion and exclusion criteria. Clinical trials, randomized and non randomized studies, classical and comparative studies, multicenter studies, *in vitro* and *in vivo* studies, case reports, longitudinal studies and reviews of the literature were included in this review. Additionally, current and previous issues of the most relevant papers were inspected, intending to obtain other articles associated to the theme. Articles that were not related to the purpose of this study were excluded from further evaluation. Finally, one textbook was included for the review.

RESULTS

One hundred and fifty-two articles met the inclusion criteria of treatment planning of dental implants in posterior jaw and were read in their entirety. The selected articles were categorized with respect to their context on space for restoration, anatomic considerations, radiographic techniques, implant selection, tilted and pterygoid implants, short implants, occlusal considerations, and success rates. The results derived from the review process were described under several different topic headings to give readers a clear overview of the literature.

DISCUSSION

Space for restoration

The discussion about the space requirements for placing an implant is very important. The mesiodistal space required is related to the type and number of teeth that will be replaced[8]. According to Misch[13], the selection of implant size is influenced by the mesiodistal distance available for implant placement. These authors indicated a guideline for this selection: (1) a distance of at least 1.5 mm must be respected between the implant and the adjacent teeth; (2) a distance of at least 3.0 mm between the implant and an adjacent implant; and (3) for the replacement of a molar teeth, a implant with a wider diameter is indicated.

If the implant-supported proshtesis is positioned with a large distance from the adjacent tooth, critical contours and cantilever forces are generated on the implant. Since the mesiodistal dimension of molar teeth is greater when compared to other teeth, a distance of at least 2.5 mm between the implant and the adjacent implant has to be respected to assure a restoration proper contours[8].

According to Gastaldo *et al*[14], a distance of 3 mm between the bone crest adjacent implants and the proximal contact point is essential, and the implant should be placed 3-5 mm away from the tooth in order to guarantee a healthy interproximal papilla.

Simşek *et al*[15] evaluated, through finite element analysis (FEA), different distances between implants that retained three unit partial prosthesis and their effects on bone stress distribution in the posterior lower jaw. Axial, horizontal and oblique forces were applied and tensile and compressive bone stresses were evaluated. The authors observed that a space of 1.0 cm was the greatest distance between the inserted two implants.

Both the mesiodistal and the buccolingual dimensions from the crestal level to the apical part of the implant site should be evaluated[16]. At least, a 6 mm of bone buccolingual extension is necessary to insert a 4 mm-wide dental implant. For diameters higher than 5 mm, a 7 mm extension is required[8]. Additionally, the intermaxillary space is an important source. A distance of 10 mm between the residual ridge and the antagonistic arch must be respected when substituting posterior teeth[8,17].

A multidisciplinary approach is considered when planning a dental implant treatment and involves orthodontics, surgery, and restorative, so that the function and aesthetics of those patients are improved[10,16,18-20]. Generally, over-eruption of opposite teeth occurs after a long period of tooth absence, which affects the restorative space. Therefore several treatment options to creat a sufficient space for restoration are available such as enameloplasty, minimal restorative therapy, orthodontic intrusion, tooth realignment, endodontic treatment and full crown preparation, segmental osteotomy for dentoalveolar extrusion and extraction[8,10,16,18,19].

Anatomic considerations: Bone quantity and density

The low-density and quantity of bone and the presence of sinus pneumatization in maxilla are relevant anatomic characteristics in the posterior region, since they can limit the implant height[21-31]. On the other hand, the mandibular canal is an important structure that could limit the installation of dental implants in lower jaws[21,32,33]. According to Jivraj *et al*[8] and Vazquez *et al*[34], a distance of at least 2 mm between the most apical part of the implant and vascular and neurologic structures must be respect.

Additionally, the mental foramen is an important mandibular structure when placing implants in the foraminal region. The mental foramen is either oval or round and is usually placed in the apical area of the second mandibular premolar or between apices of the premolars[35,36]. Nevertheless, its location may vary from the mandibular canine to the first molar[35,37].

Guidelines to evaluate the mental foramen position and the presence of mental nerve deviations have been proposed aiming to preserve the nerve, during surgeries in the foraminal area. Previously to implant insertion, a careful observation of mental nerve and foramen, through panoramic and periapical X-rays, is essential. In case of deficiency of this technique to observe the position of the nerve, the computadorized tomography scans are necessary. After the confirmation of the secure bone height, the professional can install the implants mesially or distally placed from the mental foramen or above it[34,35,37].

The lingual mandibular bone concavity is also another important factor since it increases the risks of fenestrations or perforations during implant insertion, in case of deficient buccal-lingual angulation[20,21,38].

Nevertheless, the bone density on the implant placement region affects the primary stability and in turns determines the implant treatment success[11,39,40]. Fuh *et al*[41] determined the density of trabecular bone at potential areas for implant placement. Chinese jawbones were evaluated through computed tomography (CT) in four different regions: anterior and posterior areas of maxilla and mandible. The bone densities differed between each region, being lower in the posterior area - maxilla (332 + 136 HU) and mandible (359 + 150 HU) - and higher in the anterior area -maxilla (516 + 132 HU) and mandible (530 + 161 HU). These results were similar to those of Sogo *et al*[42], who found that the bone in the posterior maxilla was classified as type Ⅲ (350-850 HU) and type Ⅳ bone (150-350 HU). These findings illustrated the necessity of choosing a specific implant design and surface treatment for the different bone density types owing to improvement of the bone-implant contact area[21]. Furthermore, cutting torque[40,43] and the resonance frequency[40,44] can be used to determine the bone quality and implant stability, respectively, and have a major effect on the osseointegration success.

Sakka *et al*[40], in a literature review, affirmed that to classify the bone quality it is important to evaluate bone morphology and characteristics of the constitutive cells. The cortical and trabecular bone ratio, and bone quantity and density have a great effect on the implant treatment longevity. Cells associated to bone quality, as macrophages, monocytes, fibroblasts, mesenchymal progenitors, osteoclasts, and cells related with angiogenesis, could influence the osseointegration of dental implants.

The implant placement is influenced by the form and contour of the edentulous alveolar ridge[21]. Infections, trauma during dental extraction, remodeling of alveolar bone after tooth extraction create localized defects on the bone[21,25,36,37,45], affecting its height and width, and consequently, influence the dental implant placement[21,28]. Some methods have been used to overcome these complications as guided bone regeneration with resorbable and nonresorbable barriers to enhance localized ridge deformities, the utilization of short-length implants, inclined implants, zygomatic or pterygoid implants, bone grafting surgeries and sinus lifting operations[21,46-52].

Del Fabbro *et al*[46] performed a systematic review of 39 selected studies in which 2046 patients underwent sinus grafting and received 6913 implants. After an accompaniment of 12 up to 75 mo, the reported survival rate was 92.5% (range, 61.2% to 100%). Results were also divided according to type of grafting materials. Overall, the survival rate of implants was 87.7% with autogenous bone, 94.9% when autogenous bone was mixed with other grafting materials, and 95.9% with nonautogenous grafting materials. Results were also reported according to type of implant surface. Overall, the survival rate was 85.6% for implants with smooth/machined surfaces, and 95.9% for implants with rough surfaces.

Radiographic techniques

Prior to implant insertion, intraoral and panoramic radiographies should be considered. But, since those techniques just provide information in a 2-dimensional view, the bucco-lingual bone width is missed[25,34,38,45,53-57].

The localization of the mandibular canal, the submandibular fossa, and the maxillary sinuses, in addition to the angulation of the alveolar crest and the bone volume are of primary importance during implant treatment planning in the posterior jaw area[22,31,32,34,36,57-60]. Therefore, the use of CT in all sliced images is suggested to indicate the most convenient dimensions of the implant and its optimal position and inclination[25,38,42,45,54-57,61]. Spiral/helical CT scanners provide images with higher quality, with tridimensional view, associated with lower radiation exposure, than conventional computerized tomography[54,62]. Nevertheless, the CT scan is kind of expensive and requires large equipment. The radiation dose is relatively high[63].

In general, the conventional CT liberates a higher dose of radiation than another option of image scan, the cone-beam computed tomography (CBCT), which offers realistically tridimensional sliced images[31,54,57,58]. Therefore, this method is useful during implant treatment planning for partial edentulous patient[57,58,64,65].

Implant selection: Number, position, diameter, and surface

The selection of the ideal number of implants is related to the bone volume and density. Since the posterior region of upper jaw presents a soft bone tissue, it is recommended to insert 3 implants to replace 3 missing teeth[8,65]. In case of one implant failure, the previous prosthesis may still be used. And when the anterior or posterior implant fails, a cantilevered prosthesis could be fabricated[8].

The use of either two or three implants relies on the prosthesis biomechanical function and is influenced by load application during chewing[8]. In cases when it is possible to install three implants, a different configuration with a tripod effect of their distribution can be realized[8,66], which provides greater bone support versus linear placement[66]. Additionally, when possible, multiple implants in posterior quadrants should be splinted. Guichet *et al*[67] observed that splinted implant restorations exhibited optimal stress distribution than non-splinted prosthesis. However, Clelland *et al*[68] and Vigolo *et al*[69] observed that splinted prosthesis did not differ significantly from individual restorations, regarding strain distribution data and peri-implant marginal bone loss, respectively.

Regarding the implant diameter, implants with small (from 3.0 up to 3.5 mm) or regular (from 3.75 up to 4.5 mm) diameters should be used for pre-molar teeth and are not indicated in molar region due to the high occlusion force transmission[21,70]. Prosthesis that does not respect the long axis of the implant tends to develop inappropriate biomechanical forces on the restoration/implant assembly[71,72]. In this case, screw loosening and implant or abutment fatigue may occur[71,73]. Moreover, the cantilever force may induce peri-implant stress and bone resorption[74,75].

Increased mechanical stability and bone-implant contact are achieved using implants with a large diameter (from 5.0 up to 6.0 mm)[21,76-78]. In addition, their use provide an effective counter acting occlusal force of the magnitude that may be observed in molar areas[21,79-81]. Finally, the wide-diameter implants mimic the emergence profile of the molar tooth[8,81].

Nonetheless, due to the presence of a soft bone tissue at posterior jaw, two implants can be indicated in the first molar area[82,83]. Two implants placed very close simulate an anatomical condition of the roots, which increase in two folds the anchorage surface area. Additionally, it eliminates antero-posterior cantilevers, decreases rotational forces and screw loosening. Nevertheless, the routine oral hygiene may be more difficult and insufficient mesiodistal space limits the placement of two implants[8,21].

According to Carvalho *et al*[21], different factors can influence when making a decision between one implant with a large diameter (5 mm) or two implants with a small or regular diameter. These factors are: bone volume and density, bone height between the residual rigde and important structures such as sinus and neurovascular canals and, the availableness of bone in a mesiodistal direction.

In relation to the surface of the implant, the use of rough surface implants has outnumbered machined implants[84-88], and it is supported by evidence of earlier and greater implant stability[84-87,89]. It is also argued that this fact prevents the necessity of a second surgical stage, and even encourages earlier or immediate loading in specific cases[80,90]. But, longitudinal studies comparing the two different surfaces using identical protocols in matched population groups and surgical sites have not been accessed. Therefore, the remaining question rises if the assumed improved longitudinal clinical findings are really the result of better science or the product promotion[89].

Tilted and pterygoid implants

The insertion of tilted implants may be an important alternative to bone grafting, guided bone regeneration, nerve lateralization, short implants, or height deficient atrophic posterior jaw[23,33,50,56,59,75,91-93]. Additionally, it allows for bicortical stabilization of the implants which reduces implant micromotion during osseointegration and enhances the implant success rate[93].

Krekmanov *et al*[94] and Aparicio *et al*[95] evaluated alternatives for implant insertion in severely atrophic maxillas. The authors suggested that a mesiodistal inclination of the implant, associated or not with a bucco-palatal direction, respects the maxillary sinus and are a treatment option for reabsorbed posterior upper jaws. More recently, in a report[93] comprising 196 tilted implants in 64 atrophic posterior mandible edentulous, an absence of osseointegration resulted in failure of only two implants, and the neurovascular structures were intact.

The pterygoid implant was first introduced to be placed in the bone pillar, that is formed by the three structures: pyramidal process of the palatine bone, pterygoid process of the sphenoid bone and maxillary tuberosity[96]. While the first two are formed by dense cortical bone, the maxillary tuberosity is based on poorer bone quality[22,24,51,96-98]. The surgeon should be aware that the maxillary artery and its branches passess through the posterior and medial regions of the maxillary tuberosity[99]. In case of full-arch implant supported restorations, the use of pterygomaxillary implants gives support and retention for the restorations and eliminate the cantilever's length that may be necessary when just anterior implants are placed[47,51,98,100].

Bahat[101] reported that 7% of the 72 implants inserted with a modified technique in the tuberosity area failed after a follow-up period of 21.4 mo, while Ridell *et al*[99] did not observe failures of any of the 22 implants placed in the same area after an accompaniment of 8 years. Peñarrocha *et al*[47] evaluated 68 pterygoid implants over 1 year of loading and found a success rate of 97.05% and a peri-implant bone loss of 0.71 mm. After that period, the patients were satisfied with the functional and esthetical aspects of the oral rehabilitation.

On the other hand, Balshi *et al*[98] found a cumulative survival rate of 90.8% of 1.608 implants placed into the pterygomaxillary region. These authors compared two-stage freehand, single-stage freehand and single-stage guided protocols. They observed that single-stage protocol exhibited higher cumulative survival rate (96.45%) than two-stage protocol (85.94%) and guided surgery (93.38%). Therefore, immediate loading of those implants is beneficial to treatment.

When implants are inserted into the tuber area, normally it is necessary to tilt the implant, which is unfavorable to the biomechanical point of view, increasing the peri-implant bone resorption and reducing implant success rates. On the other hand, previous studies showed appropriated results with tilted implants *vs* straight ones[33,59,92,95]. Maybe it occurs because the tilted implants can be longer than axial ones[99].

The use of splinted implants has been indicated to reduce the stress on tilted implants[93]. This recommendation has been originated from studies that demonstrated that splinted implants showed better stress distribution when compared to non-splinted prosthesis[67]. On the other hand, Lan *et al*[12] observed, through finite element study, that tilted implants with splinted crowns exhibited greater stress concentration, specially in implants with distal tilting. Nevertheless, additional follow-up and long-term evaluations are warranted.

Short implants

Some authors[91,102-105] have defined short implants as implants no longer than 7 mm. Others[29,106-109] have considered short implants to be implants up to 10 mm long.

The length of implants is limited to the presence of some anatomical structures as the intra-alveolar canal and the maxillary sinus, and bone resorption. In these cases, the use of short implants has been recommended[3,23,29,72,97,104,105,109-112]. From a biomechanical point of view, when an implant is loaded, the peri-implant crestal bone receives the stress from the first few threads of the implant; therefore, once a minimum implant height is osseointegrated, implant diameter is more relevant when compared to an increase in length[23,28,86,108,113-116].

To Grant *et al*[117], short implants are convenient due to: (1) usually, this technique does not require a bone grafting procedure, which results in a faster and less expensive treatment and improves the patient's confort; (2) risks during the surgery, such as nerve damage, osteotomy heat and lesions on the adjacent tooth, are reduced; and (3) there is a surgical ease, in cases of insufficient interarch spaces. However, several controversies still exist to their indication owing to: (1) reduced implant surface; thus leading to less bone-to-implant contact after osseointegration; (2) reduced surface of force distribution after loading; more pressure at the crestal bone; more resorption leading to more threads exposed, decreasing the surface of osseointegrated implant; and (3) compromised crown-to-implant ratio[118].

In case of increased crown-to-implant (C/I) ratio, the crown works as a lever arm, transferring the stress to the crestal bone around the implant[115,119], which can result in peri-implant bone loss[119,120] and problems with components of the prosthesis[66,121].

Blanes[121] found that, when the C/I ratio was higher than 2, the survival rate of the implant-retained prosthesis was 94.1%. Apparently, according to these authors, the C/I ratio did not influence the marginal bone loss. Also, Rokni *et al*[122] observed that the C/I ratio did not interfere on crestal bone loss around dental implants. Similarly, Urdaneta *et al*[73] identified the same results on single-tooth implants. However, these authors noted an increase in prosthetic complications, such as implant abutment and fracture.

Crown/Implant ratios ranging from 0.5 to 1 are important to avoid stress and bone loss at a crestal bone level, which could result in implant loss[116,123,124]. Nevertheless, Tawil *et al*[125] stated that high C/I ratios are not the most relevant agent that affect load distribution and Schneider *et al*[126] added that this increase may be used successfully in implants for single-tooth replacement in posterior jaws, except for smoking patients.

Short implants are feasible solutions in case of insufficient bone height and provide favorable force orientation and distribution[111,125]. In case of full-arch fixed dental prosthesis, short implants can be an alternative in posterior jaws to give support for the cantilever, reducing lever arms and stress loading on implants[72].

Although short implants exhibited greater failure rates that longer ones[127], some studies[3,113,128] demonstrated similar outcomes for both types of implants. Probably, these divergences resulted from other variables, such as implant surface, professional ability, bone characteristics, implant primary stability and prosthodontic protocol, which also affects the implant survival[86].

Atieh *et al*[112] performed a systematic review of 33 selected studies concerning 2573 short implants inserted in posterior upper and /or lower jaws to retain fixed partial

Table 1 Cumulative success rates of short implants placed in posterior region

Ref.	Implant surface	Implant length	N implants	Period of evaluation	Success rate (%)
Bahat[127]	Machined-surface	7 mm	-	5 to 70 mo	90.50
Winkler *et al*[130]	Machined-surface	< 10 mm	181	3 yr	93.40
Friberg *et al*[103]	Machined-surface	< 10 mm	247	8 yr	93.70
Deporter *et al*[84]	Porous-surface	7 or 9 mm	48	8.2 to 50.3 mo	100.00
Tawil *et al*[107]	Machined-surface	≤ 10 mm	269	12 to 92 mo	95.50
Griffin *et al*[113]	Hydroxyapatite-coated	8 mm	168	Up to 68 mo	100.00
Renouard *et al*[151]	Machined or oxidized surface	6 to 8.5 mm	96	2 yr	94.60
Goené *et al*[110]	Acid-etched surface	7 or 8.5 mm	311	3 yr	95.80
Misch *et al*[85]	Roughened surface	7 or 9 mm	745	6 yr	98.90
Anitua *et al*[86]	Micro-rough acid-etched surface; bioactive surface	7 to 8.5 mm	532	5 yr	99.20
Grant *et al*[117]	-	8 mm	335	up to 2 yr	99.00
Anitua *et al*[114]	-	< 8.5 mm	1.287	1 to 8 yr	99.30
De Santis *et al*[97]	Oxidized surface	< 8.5 mm	107	1 to 3 yr	98.10
Maló *et al*[104]	Oxidized surface	7 mm	217	12 mo	95.00
Pieri *et al*[111]	-	6 mm	61	2 yr	96.80
Perelli *et al*[27]	Porous-surface	5 or 7 mm	110	5 yr	90.00
Jiansheng *et al*[109]	Hydroxyapatite-coated and ankylos	5.7 to 8 mm	162	2 yr	99.40
Slotte *et al*[29]	Acid-etched surface	4 mm	100	2 yr	92.30
Deporter *et al*[88]	Porous-surface	7 or 9 mm	48	10 yr	95.50

prosthesis. A survival rate of 98% was reported, after an accompaniment period of 5 years. When comparing short and long implants, no important differences were observed. The authors affirmed that short implants represents a viable treatment option than longer ones and that the survival rate is not related to implant surface, design or width.

Morand *et al*[118] reported that the one improvement that had the most dramatic effect in improving implant treatments was the evolution of implant surfaces from machined/polished to rough-textured surfaces. Table 1 confirms this information, evidencing higher success rates for rough surfaced implants. The percentage of bone-implant contact can be modified by the surface condition of the implant. This is important because the greater the percentage of bone contact, the lesser stress is applied to the bone-implant interface[86]. Therefore, it is possible to assure that with careful case selection criteria, the longevity of short implants is greater than 90%.

Nevertheless, besides the high success rates, the most important aspect of treatment with short implants is the case selection[23,118]. Facing severe bone resorption associated with poor bone quality and overload, bone grafting techniques could prevent failure in such associations. The success rate of short implants in patients with more favorable conditions is greater which makes it the best treatment option[129].

Occlusal considerations

The excess of loading in posterior jaws associated with the functional activity of the mandible in a buccal-lingual direction and with cusp inclination can create lateral forces onto implants[9,130-132]. Thus, during implant treatment planning, a broad evaluation of the loading is essential, since a bending moment at the peri-implant bone can result in prosthesis components damages and/or crestal bone loss[20,66,115,132,133].

Various factors can overload an implant. Rangert *et al*[134] identified two principal factors that justify this excess of loading: geometric and occlusal load reasons. The first one is related with the implant number and position, and with the prosthesis configuration. The second factor includes lateral occlusal force components and parafunctional habits, which increase the loading onto implant surfaces. If forces are higher than normal, the implant can be overloaded.

Ogawa *et al*[135] affirmed that a decrease in number of supporting implants is to promote an increase in implant loading. The bending moments were higher when prosthesis were supported by three implants than four or five implants. Additionally, concerning the implant position, the smallest implant distribution increased the bending moments.

The prevention of occlusal overload should be the focus of any treatment planning[66,136]. In case of no alternative, the prosthesis should be protected from injuries with an inter-occlusal device[67,93]. Some guidelines were reported aiming to respect physiologic limits for occlusal loading: optimized passive fit, reduction of cantilevers, adequate selection of the dimensions and number of implants, presence of a correct preload in the abutment screw and a proper buccal-lingual dimension and cusp inclination of the crown[66,132,133,137-139].

Furthermore, the principles of implant occlusion are mostly based on the traditional principles of conventional restoration. Anterior guidance should be presented and during lateral excursion, a posterior disclusion is indicated for working and non working sides. Group function disocclusion is indicated when the canine is compromised[8].

Payer *et al*[140] evaluated the outcome of edentulous posterior mandible treated with implant-retained immediate provisional prosthesis. According to these authors, immediately loaded implants exhibited similar results when

Table 2 Cumulative success rates of implants placed in posterior region

Ref.	N implants	Posterior zone	Period of evaluation	Implant systems	Success rate (%)
Jemt *et al*[4]	259	Maxilla and mandible	5 yr	Nobelpharma	97.20
Zarb *et al*[144]	105	Maxilla and mandible	2.6-7.4 yr	Nobelpharma	94.30
Block *et al*[142]	443	Mandible	10 yr		79.30
Becker *et al*[143]	282	Maxilla and mandible	6 yr	Branemark	89.40
Bahat[145]	660	Maxilla	10 yr	Branemark	93.40
Attard *et al*[5]	106	Maxilla and Mandible	10 yr	Nobel biocare	94.00
Attard *et al*[152]	432	Maxilla and Mandible	15 yr	Nobel biocare	91.60
Jebreen *et al*[7]	141	Maxilla and Mandible	12-69 mo	ITI	96.45
Blanes *et al*[6]	192	Maxilla and Mandible	10 yr	ITI	97.90
Huynh-Ba *et al*[153]	273	Maxilla	8 yr	-	94.90
Maló *et al*[70]	247	Maxilla and Mandible	11 yr	Nobel biocare	95.10
Schneider *et al*[126]	100	Maxilla and Mandible	5 yr	Nobel biocare and straumann standard	95.80

compared to conventionally loaded implants. During a follow-up period of 5 years, the survival rate was 95%.

Similarly, Degidi *et al*[136] performed a randomized clinical trial that aimed to evaluate the effect of immediately loaded and immediately restored implants for edentulous posterior lower jaws. The authors found that both procedures are predictable. No differences in marginal bone loss or survival rate were observed.

Nonetheless, concerning the conditions of early-loaded implants in the posterior upper and lower jaws, Kim *et al*[141] observed that, although early loading is a predictable procedure, it is important to be careful with maxillary implants.

Success rates

Table 2 illustrates the success rates of implants inserted in the posterior jaws of patients with partial edentulism. Favorable success rates were observed when edentulous areas were replaced with implants, except for the study of Block *et al*[142], which related lower success rates for implants inserted in posterior inferior jaws (78.5% for first molars and 71.8% for second molars). Some studies showed distinct success rates for those implants placed in the posterior regions of maxilla and mandible, with lower success rates for the posterior maxilla[4,6,7,143]. However, Zarb *et al*[144] obtained a success rate of 97.6% for the 41 implants placed in the upper jaw and, of 92.2% for the 64 implants placed in the lower jaw, after a loading period of 2.6 to 7.4 years.

The non-standardization between and within studies has increased the range in success rates, *e.g.*, 79.3% to 97.9%. The differences in study design may be the driven force toward those results. Factors such as length, number, diameter and surface of the implants, bicortical fixation, and extended healing periods contribute to a good long-term success rate[4,143,145]. When the implants are placed into soft bone tissues or inserted in regions with insufficient bone height that demands grafting procedures such as sinus lifting, lack of osseointegration[11,25,146] and failure after loading[147] are prone to occur. The same problem occurs in case of smoking patients[11,148]. Additionally, the lack of oral hygiene may be another initial factor of implant loss[133,145,149], while bicortical fixation may improve osseointegration and reduce bone resorption[116,145,150].

COMMENTS

Background

The osseointegrated implants allow a functional rehabilitation for patients with partial edentulism, since they improve the occlusion and retention of the prosthesis and the bone maintenance. However, the posterior region of the maxilla and mandible requires special attention due to their anatomical and occlusal characteristics.

Research frontiers

Implant-retained prosthesis is a common procedure for posterior partially edentulous jaw rehabilitations. The knowledge regarding this topic involves maxillofacial anatomy, physiology and radiology, oral implantology, occlusion and prosthodontics, and is directly related with patient's psychological aspects.

Innovations and breakthroughs

This review of the literature presents an accurate description of the main articles that evaluated a rehabilitation with dental implants in the posterior maxilla or mandible. Different topics, such as space for restoration, anatomic considerations, radiographic techniques, selection of number, diameter, position and length of implants, occlusal considerations and success rates, were carefully discussed in this article.

Applications

The study findings suggest that professionals need to minutely evaluate the treatment parameters to guarantee the longevity and success of the rehabilitation.

Terminology

Crown-to-implant (C/I) ratio is a guideline related with the longevity and survival of the prosthesis, since a higher C/I ratio represents a lever arm of the crown over the peri-implant bone area, which can result in bone loss.

Peer review

The work is interesting,and useful to the clinicians.

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P- Reviewer: Chen S, Ferreira MM, Vieyra J **S- Editor**: Ji FF
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