Treatment Options for the Posterior Edentulous Jaw: Surgical Options for the Posterior Mandible

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ABSTRACT

This article focuses on the surgical and prosthodontic options for implant placement in the posterior mandible. The authors draw on the existing literature and their 20 years of experience to describe the management of this anatomical region. Contemporary implant dentistry involves established rehabilitation strategies that satisfy the criteria of safety, predictability and short treatment duration in a cost-effective way.

Keywords: Dental implants, posterior mandible, partial edentulism, fixed partial denture, implant surgery

INTRODUCTION

A wide range of indications for dental implant treatment and high patient acceptance of this modality rely upon the safety of the surgical and prosthetic procedures employed. Therefore, the clinician should only implement well-established, predictable procedures with high success rates, low complication rates, minimal invasiveness, and low cost. Procedures satisfying these prerequisites employ the use of prosthetic-driven planning, optimized surgical techniques and highly evolved implant technology.

In the absence of trauma or pathology, the posterior mandible is characterized by sufficient cortical bone density to sustain dental implant-supported reconstructions but is subject to demanding loading conditions. The loading conditions in the posterior mandible are the same as in the posterior maxilla but the bone density in the posterior maxilla is lower (Cordaro et al. 2009). A risk inherent in placing an implant in the edentulous posterior mandible is injury to the inferior alveolar nerve. Hence, the use of short implants has considerably facilitated surgery in this area (Block 2014). Furthermore, it is well established that the anterior and posterior mandibles exhibit the highest cumulative implant success rate (Buser et al. 1997).

This article focuses on the surgical management of implant placement in the posterior mandible. Options are described with reference to the literature and to practical experience derived from more than 20 years of close collaboration between a team of oral surgeons, general practitioners and dental laboratory technicians in a large private clinic setting.

TREATMENT PLAN

Prosthetic planning is the initial step in the treatment process and follows collection of diagnostic records. Classically, prosthetic planning starts by mounting diagnostic casts on an articulator to evaluate the occlusion and the vertical dimension of occlusion. Thereafter, a diagnostic wax-up is created to visualize the planned prosthetic outcome. The surgeon performs adjustments according to the surgical requirements, evaluates the potential need for bony augmentation and selects the lengths and diameters of the implants. Next, the diagnostic wax-up is generally shown to the patient to present the planned treatment outcome. If the plan is approved by the patient, the prosthodontist validates the diagnostic wax-up, the dental laboratory technician produces the surgical guide, and the surgery can be undertaken.

Currently, a digital workflow employing the use of intra-oral scanners, computer-aided design/computer-aided manufacturing (CAD/CAM) solutions (Straumann® CARES®, Straumann AG, Basel, Switzerland; CEREC®, Sirona Dental GmbH, Wals bei Salzburg, Austria) and planning software (coDiagnostiX™; Straumann AG; SimPlant, Dentsply IH SA, Yverdon-les-Bains, Switzerland) facilitates the creation of digital diagnostic impressions and digital drill-guide design.

IMPLANT CONSIDERATIONS

Distribution

In accordance with the results of long-term studies that evaluated the number of occlusal units necessary for sufficient masticatory function (Belser et al. 2000), we do not routinely extend implant-based restorations distal to the first molar area in the case of a distally shortened arch. The reasons for this are functional, practical and hygienic. When considered from the prosthetic aspect, replacement of the second molar is often impeded by restricted restorative space. When considered surgically, placement of an implant at the second molar site may be contraindicated by deep mandibular lingual concavities. Therefore, the second molar is rarely considered for the placement of an implant supporting a single crown or a bridge.

Type
We mostly use tissue-level implants in the posterior mandible: they are perfectly adapted to single-stage surgery and the mechanical strain imposed by masticatory forces. We do not recommend bone-level implants for routine placement in the posterior mandible: in our opinion they are more suitable for esthetic indications in anterior areas.

As part of the restorative project, the practitioner must take into account that patients frequently report discomfort with large crowns. Usually, we construct restorations supported by dental implants in the posterior mandible to be narrower than the teeth being replaced. Regular-neck implants that are 4.8 mm in diameter are preferable for this purpose because they are better adapted to vestibulo-lingually undersized restorations compared with natural teeth. Wide-neck implants are only used to rehabilitate first molar sites when the second molars are still present in order to optimize the emergence profile. While the replacement of a second molar distal to a natural first molar is not advisable (see above), in theory, the replacement of second molars should be also performed with wide-neck implants.

Length
Intrusion into the mandibular canal increases the risk of inferior alveolar nerve damage, which may lead to altered sensation, anesthesia, paresthesia or hyperesthesia to such an extent that it can affect a patient's quality of life (Misch 2008). Therefore, the position of the inferior alveolar nerve must be known before conducting implant procedures, particularly in the mandibular premolar region. Most patients have a mental foramen located apically between the two premolars or positioned below the second premolar (Arx et al. 2013). The distance from the mandibular canal to the upper border of the mandible is, on average, 15.8 mm in most patients with an absent second premolar, and 16.1 mm in those with an absent first molar (Hsu et al. 2013). It is recommended that the position of the mental foramen and the possibility that an anterior loop of the mental nerve might exist, be surgically corroborated prior to the insertion of implants in the premolar region (Greenstein & Tarnow 2006).

When the distance from the mandibular canal to the upper border of the mandible is greater than 13 mm, standard implantation is carried out (Kahnberg 2014). During drilling and implant insertion, a safety zone of at least 2 mm must be left between the osteotomy or the implant and the roof of the mandibular canal (Nedir et al. 2004, Greenstein & Tarnow 2006, Misch 2008). This distance, recommended for safe implantation, should be systematically respected: no incidences of paresthesia were reported during our 20-year experience in implant dentistry. On a routine basis, panoramic radiography is sufficient to evaluate the available bone height prior to implant insertion in the posterior mandible; cross-sectional imaging techniques can provide further preoperative information for sinus augmentation procedures and sinus-related structures (Harris et al. 2012) but are mostly unnecessary in the posterior mandible (Vazquez et al. 2008). Under conditions of limited bone height, intra-operative radiography can be also used with a depth gauge in place to evaluate the distance between the osteotomy and the nerve (Fig. 1).

For standard placement, 10-mm-long implants are our first choice. They are used even when it is possible to place longer implants. However, the proximity of the mandibular canal often limits implant selection to shorter implants. An alternative option is the nerve transposition procedure. This procedure is associated with high morbidity and a high rate of nerve damage (Jensen & Nock 1987). It is therefore not performed at our dental clinics where vertical augmentation procedures are preferred. Insertion of shorter implants is recommended when the distance between the crestal area and the mental foramen or the mandibular canal is <11 mm (Garcia Blanco & Puia 2016). It has been shown that the survival rate of 8-mm-long implants placed in the posterior mandible is 99% (Grant et al. 2009). Improvements in implant surfaces have allowed the use of 6-mm and recently 4-mm implants with a mid-term survival rate of up to 92% over 5 years (Slotte et al. 2015). The crown-to-implant ratio may not impact implant survival or peri-implant bone loss for implants ≥6 mm in length (Huynh-Ba 2015, Anitua et al. 2015) but further studies are needed to assess the effect of a high crown-to-implant ratio on the survival of extra-short implants (Anitua et al. 2014). Because of the increased risk, it is extremely uncommon for 4-mm-long implants to be used at our clinics. Vertical augmentation with guided bone regeneration (GBR) makes it possible to avoid using very short implants and long crowns, but is more challenging than placing short implants, necessitates an additional surgery, is more invasive and can induce more complications. However, it provides the patient with a more comfortable restoration: the crowns can be made shorter and more esthetic, and access for cleaning is facilitated.

In the mandible, the standard replacement of three teeth is performed using two implants of 10 mm in length and a 3-unit fixed dental prosthesis (FDP). For implant surgery planning, more implants are placed when a 6-mm implant is needed. One 6-mm implant per prosthetic element must be considered and restored with splinted implant-supported crowns whenever possible (Fig. 1).

Position
Competent treatment planning is key to the surgical and long-term success of implant-based restorations. For ideal occlusal screw positioning and prosthesis-driven implant placement, the production of a diagnostic wax-up as well as a surgical guide is essential (Cordaro 2014). At our clinics, implant placement in the posterior mandible is prosthetically driven using surgical guides based on a prosthetic restoration plan. Whenever possible and when the tooth to be replaced is in an appropriate position, an impression of the tooth is taken before extraction, and may be used as *a de facto* wax-up.

In the past we used Standard tissue level implants with a smooth neck section of 2.8 mm (Straumann). These implants were placed in a supra-mucosal position which facilitated removal of excess cement. Today, with higher esthetic expectations on the part of patients also in the posterior mandible, Standard Plus implants with a reduced collar height of 1.8 mm (Straumann) are now used on a routine basis in our clinics. The Standard Plus allows for greater flexibility in apico-coronal placement so that its shoulder can be placed slightly sub-mucosally. However, crowns cemented on implants placed sub-mucosally are associated with a risk of impaction of cement. Consequently, under such conditions we recommend the avoidance of cemented prostheses. When considering the use of screw-retained restorations, one must keep in mind, however, that optimal implant positioning in the oro-facial and mesio-distal dimensions becomes even more critical than for cement-retained restorations.

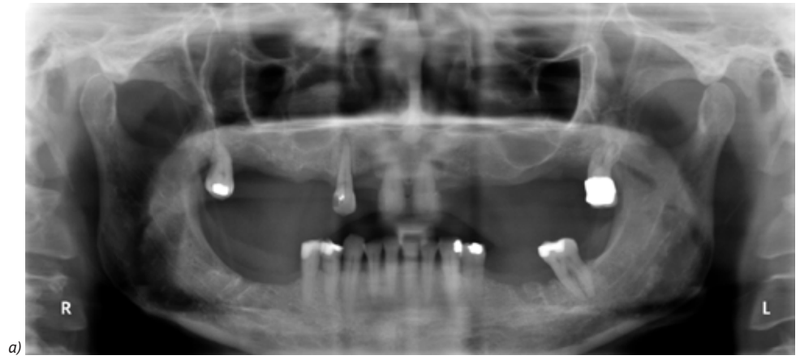
Fig. 1: Use of 6-mm-long implants and narrow implant

Patient: Female, 63 years old, edentulous for at least 3 months

Right side: Two 6-mm splinted implants (Standard Plus; Straumann AG, Basel, Switzerland).

Left side: One 6-mm implant (Standard Plus) splinted with one 8-mm narrow implant (diameter: 3.3 mm, Standard Plus)

(a) Initial orthopantomogram (b) Intra-operative radiographs. Use of a depth gauge for implant positioning (c) Radiographs taken 5 years after loading. No alteration in sensation was reported by the patient



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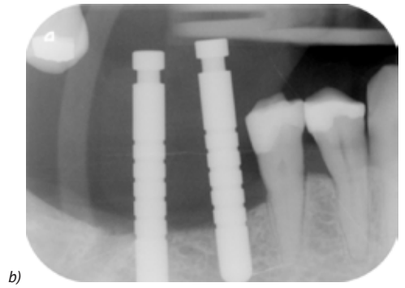

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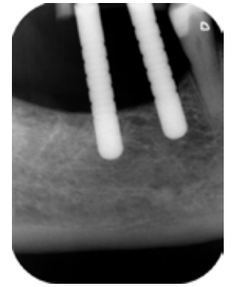

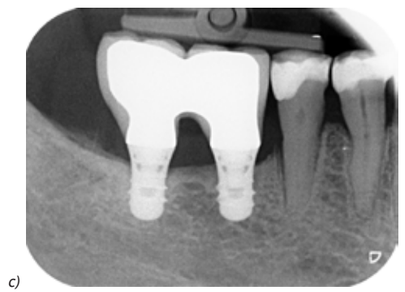

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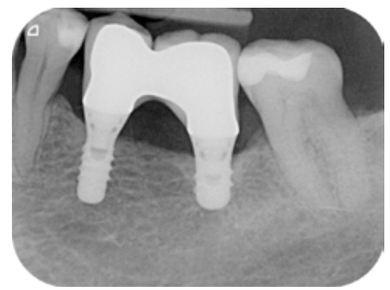


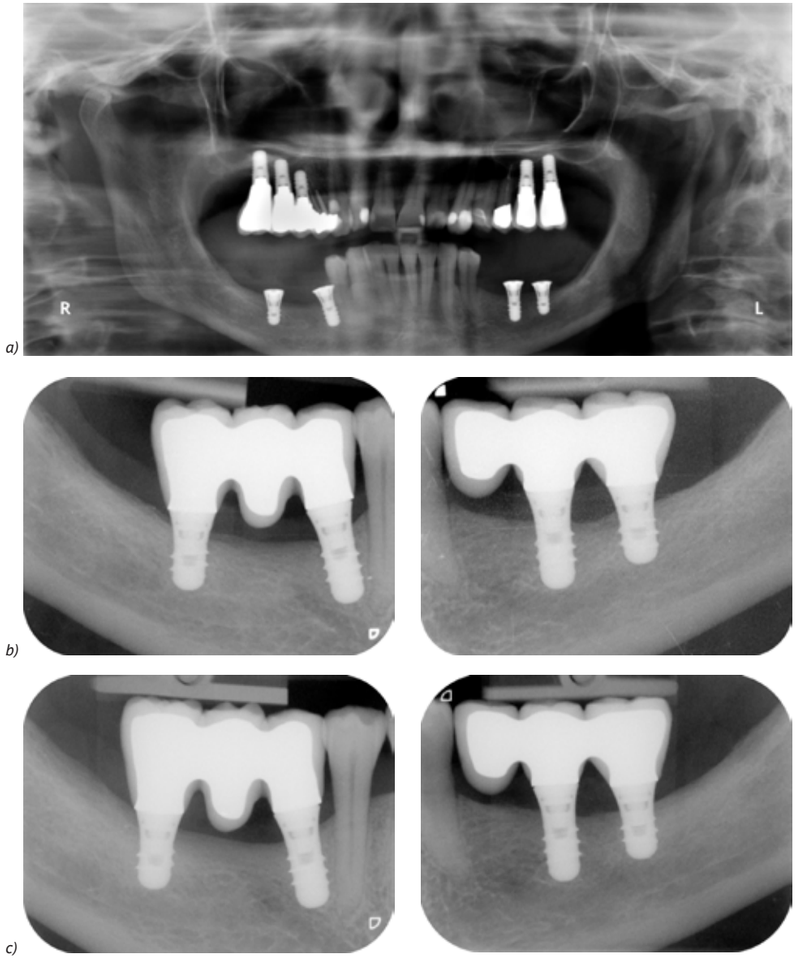


Fig. 2: A case of mesial extension.

Patient: Female, 53 years old, edentulous for at least 1 year

Right side: Although a 6-mm-long implant was indicated distally, no implant was placed under the intermediary element because of the proximity of the nerve

Left side: Because of an extremely thin crest and limited bone height above the mental foramen, two distal implants were placed with a mesial extension

(a) Post-operative orthopantomogram (b) Radiographs taken immediately after loading (c) Radiographs taken 1 year after loading

SURGERY

Bone augmentation

In the mandibular region, the available bone width is generally sufficient for implant placement. Therefore, lateral bone augmentation of the alveolar crest prior to implant placement is seldom necessary, especially in the molar area. The premolar area is narrower: implants of reduced diameter (3.3 mm) can be used (Fig. 1) or simultaneous lateral grafting can be performed. In patients with multiple edentulous sites, these implants are combined with larger implants and the superstructure is splinted.

In 2009, reduced-diameter implants made with titanium-zirconium alloy (Roxolid®; Straumann AG) demonstrating enhanced mechanical properties came on the market. Since their introduction, the indications for simultaneous lateral grafting in the premolar region have decreased drastically. In our clinics, augmentations are performed less often in the posterior mandible compared with all other regions.

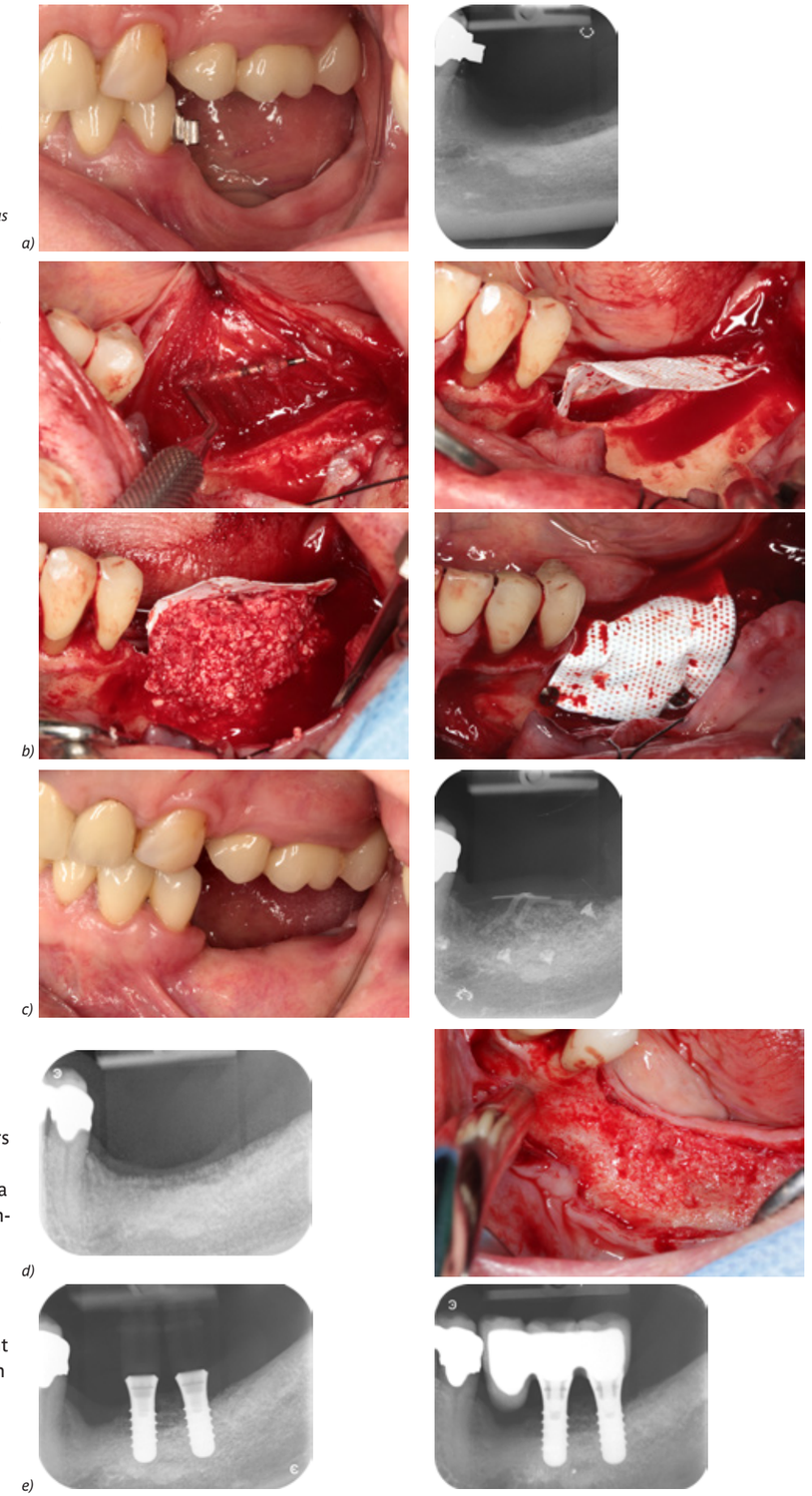
The preferred method for treating two edentulous sites in the posterior region is to use two splinted implants. For three-unit edentulous sites, fixed dental prostheses with a central pontic are preferred. Extension cantilever units are used when the crest is too thin to accommodate an implant or when the available bone height above the mental foramen is insufficient (Nedir et al. 2006; Fig. 2). Use of a mesial cantilever makes grafting above the mental nerve loop unnecessary.

In rare cases of extreme vertical or horizontal atrophy, implants have to be placed several months after the augmentation procedure. Augmentation can be performed with the block bone graft (Levin et al. 2007) and GBR (Bell et al. 2002) techniques. With both techniques, an adequate bone volume and esthetic result can be achieved. Because the use of autogenous block bone grafts is more invasive and introduces additional morbidity compared to the GBR technique, the latter technique is preferred at our clinics. It involves the creation of a space that is maintained by a barrier membrane and filled with bone material. Several papers have reported the use of autogenous bone chips or xenograft material combined with a non-resorbable membrane such as titanium-reinforced expanded polytetrafluoroethylene (e-PTFE) membrane (Rocchietta et al. 2008). Lateral bone augmentation is more predictable than vertical bone augmentation. Figure 3 describes the case of a patient who underwent vertical ridge augmentation with GBR.

Fig. 3: Ridge augmentation with guided bone regeneration

Patient: Female, 62 years old, extreme mandibular atrophy

(a) Initial situation (b) Augmentation step: The region was filled with autogenous bone chips and Bio-Oss® (Geistlich AG, Wolhusen, Switzerland). A non-resorbable titanium-reinforced barrier membrane (Cytoplast®, Flexident AG, Stansstad, Switzerland) was placed over the graft and fixed with tacks. The flap was sutured (c) Three months after augmentation, the membrane was removed (d) Nine months after augmentation, the implants were placed (Standard Plus; Straumann AG, Basel, Switzerland; diameter: 4.1 mm, length: 8 mm) (e) Four months after implant placement, prosthetic and loading steps were carried out



Preservation of keratinized mucosa
The preservation of keratinized soft tissue around implants may favorably influence implant success and prevent peri-implantitis. It increases the mucosal attachment and consequently improves the subjective comfort of patients and their ability to clean the site. The width of the keratinized mucosa must be noted before surgery. In patients in whom this zone is narrow, it is important to make the incision line along the crest of the edentulous ridge in the keratinized tissue. This preserves the attachment of the keratinized mucosal band on the vestibular and lingual mandibular sides. The caution exercised here can be considered simple but essential: it allows for long-term implant function without further complicated mucogingival surgery.

TIMING

Healing after tooth extraction
Immediate implant placement after tooth extraction is not recommended in the posterior mandible because of possible implant malpositioning inconsistent with optimal prosthesis-driven rehabilitation (Torabinejad et al. 2014). Implant surgery must be carried out at least 4 months after the extraction of multi-radicular teeth to achieve complete re-ossification of the cortical plate. For mono-radicular teeth, 3 months are sufficient. Use of a removable provisional partial denture is usually not recommended during healing of the site. We do not recommend filling the extraction socket with biomaterials.

Loading protocol
A healing time of 6 - 8 weeks before loading is considered routine for the majority of clinical situations in the posterior mandible, either with single crowns or FDPs (Cordaro et al. 2009). Provisional crowns and bridges are not routinely used in our clinics unless the intermaxillary relationship cannot be validated.

The duration of the entire treatment is about 6 months. During this period, over-eruption of opposing teeth has to be controlled, for example by means of splinting the potentially over-erupting tooth to an adjacent tooth.

CONCLUSION

This article focused on the surgical management of implant placement in the posterior mandible. The authors draw upon practical experience derived from more than 20 years of multidisciplinary collaboration at their network of clinics. They have established a surgical and prosthetic workflow starting with treatment planning and implant considerations such as distribution, type, length and position, followed by surgery including bone augmentation and preservation of keratinized mucosa, and finishing with timing in respect to tooth extraction and loading. Adherence to the workflow described in this article has contributed to the safe, predictable clinical management of the rehabilitation of the edentulous posterior mandible and led ultimately to satisfying solutions for the patients at Ardentis dental clinics.

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REFERENCES

Anitua, E., Alkhraist, M.H., Piñas, L., Begoña, L. & Orive G. (2014) Implant survival and crestal bone loss around extra-short implants supporting a fixed denture: the effect of crown height space, crown-to-implant ratio, and offset placement of the prosthesis. *The International Journal of Oral & Maxillofacial Implants* **29**: 682–689.

Anitua, E., Piñas, L. & Orive, G. (2015) Retrospective study of short and extra-short implants placed in posterior regions: influence of crown-to-implant ratio on marginal bone loss. *Clinical Implant Dentistry & Related Research* **17**: 102–10.

Arx, T. von, Friedli, M., Sendi, P., Lozanoff, S. & Bornstein, M.M. (2013) Location and dimensions of the mental foramen: a radiographic analysis by using cone-beam computed tomography. *Journal of Endodontics* **39**: 1522– 1528.

Bell, R.B., Blakey, G.H., White, R.P., Hillebrand, D.G. & Molina, A. (2002) Staged reconstruction of the severely atrophic mandible with autogenous bone graft and endosteal implants. *Journal of Oral and Maxillofacial Surgery* **60**: 1135–1141.

Belser, U.C., Mericske-Stern, R., Bernard, J.P. & Taylor, T.D. (2000) Prosthetic management of the partially dentate patient with fixed implant restorations. *Clinical Oral Implants Research* **11(Suppl.)**: 126–145.

Block, M.S. (2014) Chapter 2. Surgery of the Posterior Mandible. In: Block, M.S. (ed). Color Atlas of Dental Implant Surgery, Third Edition, 51–115, Saint-Louis MO: Saunders, Elsevier Inc.

Buser, D., Mericske-Stern, R., Bernard, J.P., Behneke, A., Behneke, N., Hirt, H.P., Belser, U.C. & Lang N.P. (1997) Long-term evaluation of non-submerged ITI implants. Part 1: 8-year life table analysis of a prospective multi-center study with 2359 implants. *Clinical Oral Implants Research* **8**: 161–172.

Cordaro, L., Torsello, F. & Roccuzzo, M. (2009) Implant loading protocols for partially edentulous maxillary posterior sites. *The International Journal of Oral & Maxillofacial Implants* **24(Suppl.)**: 158–168.

Cordaro, L. (2014) Chapter 3. Preoperative Assessment and Planning. In: Chen, S., Buser, D. & Wismeijer, D. (Eds). Ridge Augmentation Procedures in Implant Patients. A Staged Approach. ITI Treatment Guide Volume 7, 13-28, Berlin Germany: Quintessence Publishing Ltd.

Harris, D., Horner, K., Gröndahl, K., Jacobs, R., Helmrot, E., Benic, G.I., Bornstein, M.M., Dawood, A. & Quirynen, M. (2012) E.A.O. guidelines for the use of diagnostic imaging in implant dentistry 2011. A consensus workshop organized by the European Association for Osseointegration at the Medical University of Warsaw. *Clinical Oral Implants Research* **23**: 1243–1253

Garcia Blanco, M. & Puia. S.A. (2016) Safety zone to mandibular canal for posterior mandible implant surgeries.
Grant, B.T., Pancko, F.X. & Kraut, R.A. (2009) Outcomes of placing short dental implants in the posterior mandible: a retrospective study of 124 cases. *Journal of Oral and Maxillofacial Surgery* **67**: 713–717.

Greenstein, G. & Tarnow, D. (2006) The mental foramen and nerve: clinical and anatomical factors related to dental implant placement: a literature review. *Journal of Periodontology* **77**: 1933–1943.

Hsu, J.T., Huang, H.L., Fuh, L.J., Li, R.W., Wu, J., Tsai, M.T., Shen, Y.W. & Tu, M.G. (2013) Location of the mandibular canal and thickness of the occlusal cortical bone at dental implant sites in the lower second premolar and first molar. *Computational and Mathematical Methods in Medicine* **2013**, Article ID 608570.

Huynh-Ba, G. (2015) Crown-to-implant ratio? What is the latest? *The International Journal of Oral & Maxillofacial Implants* **30**: 259-261.

Jensen, O. & Nock D. (1987) Inferior alveolar nerve reposition in conjunction with placement of osseointegrated implants: A case report. *Oral Surgery, Oral Medicine, Oral Pathology* **63**: 263–268.

Kahnberg, K.E. (2014) Implant placement in the posterior mandible. In: Pogrel, M.A., Kahnberg, K.E. & Andersson, L. (Eds). Essentials of Oral and Maxillofacial Surgery. 150–160, Chicester, United Kingdom: Wiley- Blackwell.

Levin, L., Nitzan, D. & Schwartz-Arad, D. (2007) Success of dental implants placed in intraoral block bone grafts.
Journal of Periodontology **78**: 18–21.

Misch, C.E. (2008) Root Form Surgery in the Edentulous Anterior and Posterior Mandible: Implant Insertion. In: Misch, C.E. (Ed). Contemporary Implant Dentistry. Third Edition, 684–719, Saint-Louis MO: Mosby Inc, Elsevier Inc.

Nedir, R., Bischof, M., Briaux, J.M., Beyer, S., Szmukler-Moncler, S., Bernard, J.P. (2004) A 7-year life table analysis from a prospective study on ITI implants with special emphasis on the use of short implants. Results from a private practice. *Clinical Oral Implants Research* **15**: 150–157.

Nedir, R., Bischof, M., Szmukler-Moncler, S. & Samson, J. (2006) Prosthetic complications with ITI dental implants. Results from an up to 8-year experience in private practice. *The International Journal of Oral & Maxillofacial Implants* **21**: 919–928.

Rocchietta, I., Fontana, F. & Simion, M. (2008) Clinical outcomes of vertical bone augmentation to enable dental implant placement: a systematic review. *Journal of Clinical Periodontology* **35(Suppl. s8)**: 203–215.

Slotte, C., Grønningsaeter, A., Halmøy, A.M., Öhrnell, L.O., Mordenfeld, A., Isaksson, S. & Johansson, L.Å. (2015) Four-millimeter-long posterior-mandible implants: 5-year outcomes of a prospective multicenter study. *Clinical Implant Dentistry and Related Research* **17(Suppl. S2)**: e385–395.

Torabinejad, M., Goodacre, C. & Sabeti M. (2014) Factors Involved in Single Implants. In: Principles and Practice of Single Implant and Restoration, 35–52, Saint-Louis MO: Saunders, Elsevier Inc.

Vazquez, L., Saulacic, N., Belser, U.C. & Bernard J.P. (2008) Efficacy of panoramic radiographs in the preoperative planning of posterior mandibular implants: a prospective clinical study of 1527 consecutively treated patients. *Clinical Oral Implants Research* **19**: 81–85.