

Zirconia Implants Supporting Overdentures: A Pilot Study with Novel Prosthodontic Designs

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Limited clinical research identifies prosthodontic perspectives of novel designs for zirconia implants supporting overdentures. Four pilot study participants were selected before a planned randomized clinical trial on zirconia implants supporting overdentures. Novel designs for maxillary four-implant overdentures (quadrilateral design) and mandibular three-implant overdentures (tripodal design) were used with 28 implants (maxilla, $n = 16$; mandible, $n = 12$). Four implants failed to achieve osseointegration prior to loading. At the 1-year follow-up appointment, all implants were surviving, the overdentures were in function, and there were no clinical signs of wear of the attachment system. A proof-of-principle for prosthodontic perspectives of a novel design using one-piece zirconia implants supporting maxillary and mandibular implant overdentures was achieved. *Int J Prosthodont* 2013;26:277–281. doi: 10.11607/ijp.2903

Treatment approaches have seldom addressed resolving edentulism by recommending implant overdentures in both arches.¹ The primary aim of implant overdentures is to provide edentulous patients with improved retention and stability of their prostheses, enhance quality of life, and minimize prosthodontic maintenance issues. Modern shifts in treatment options toward zirconia implants include edentulous patients who may be sensitive to titanium implants and metallic attachment systems.²

Implant overdenture designs involve various implant distributions and attachment systems with significant variation between prosthodontic designs used for the edentulous maxilla and mandible. More often than not, two splinted or unsplinted interforaminal implants are recommended to rehabilitate the edentulous mandible,³ but the additional use of posterior mandibular implants is rare. Frequently, to

address the problems of single complete maxillary dentures opposing natural teeth, a minimum of four implants independent of the attachment system used are advocated for maxillary overdentures.⁴ Compared with major surgical interventions for the reconstruction of severely atrophic maxillae, more conservative approaches for implant positioning using alternative sites such as the midpalatal or incisal foramen area are now being explored.^{5,6} The aim of this research is to present outcomes of a pilot study using a novel design for zirconia implants supporting maxillary and mandibular implant overdentures.

Materials and Methods

Prior to the commencement of a randomized clinical trial, this pilot study involving four participants who were sequentially selected (two men and two women, mean age: 59.8 years) from patients requesting oral implant treatment at the Sir John Walsh Research Institute, School of Dentistry, University of Otago, New Zealand. The participants could not be randomly selected but were chosen based on their maladaptive nature to complete dentures and ability to constitute proof-of-principle to show the applicability of the proposed design. Ethical approval was obtained from the Lower South Regional Ethics Committee, New Zealand. Participants who were smokers or medically compromised were excluded. Preoperative panoramic, lateral cephalometric, and axial cross-sectional tomograms were taken to ensure a sufficient amount of bone for implant placement at the proposed sites. Each participant received diagnostic complete dentures that were duplicated and used as surgical guides.

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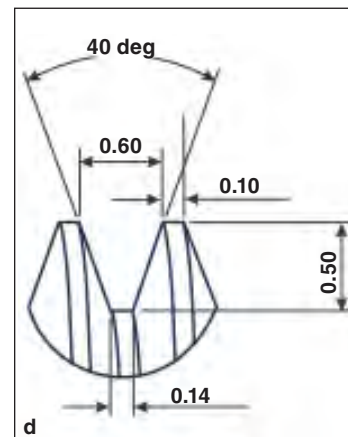
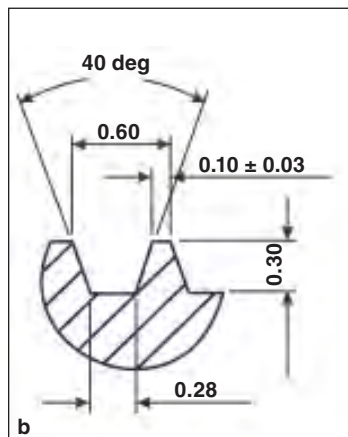
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Figs 1a and 1b (a) Maxillary crestal zirconia implant (3.8 × 11.5 mm). (b) Schematic drawing showing the thread design: 0.6-mm pitch, 0.1-mm width, and 0.3-mm pitch depth.

Figs 1c and 1d (c) Zirconia implant placed in either the incisive foramen, midpalatal, or mandibular ridge. (d) Schematic drawing showing the thread design: 0.6-mm pitch, 0.1-mm width, and 0.5-mm pitch depth.



The proposed maxillary quadrilateral design involved four oral implants at the midpalatal, incisive foramen, and bilateral premolar regions. These implants were to be positioned in both primary and secondary stress-bearing areas of the edentulous maxilla⁷ in accordance with the biomechanic principles of removable partial denture prosthodontics. The quadrilateral design would result in additional fulcrum lines, and the most anteriorly positioned implant would act as an indirect retainer, depending on the direction of force. This would minimize tissue-ward movement of the prosthesis when occlusal dislodging forces are applied. With this design, reduced implant overdenture movement and stresses at bone-implant interfaces are anticipated.

The proposed mandibular tripodal design involved three oral implants at the midsymphyseal and bilateral molar areas. Building on the historic philosophy of staggered implant placement, as well as acknowledging the success of mandibular midsymphyseal implants, two additional posterior implants would further enhance stability, support, and retention of the prosthesis. The placement of the posterior implants modifies the commonly seen Kennedy Class I type of implant-and-mucosa supported overdentures to a fully implant-supported Kennedy Class III design.

Surgical Procedures

Maxillary and mandibular one-piece zirconia implants with ball abutments (Southern Implants) were placed at separate appointments by an experienced oral and maxillofacial surgeon. The zirconia implants

consisted of 95% zirconia and a 5% combination of yttria and alumina. The one-piece zirconia implants varied in diameter and length according to the site of implant placement. The diameter of the maxillary crestal implants was 3.8 mm (Fig 1a) whereas the incisive foramen and midpalatal implants were either 5 or 7 mm in diameter (Fig 1c). Both crestal and midpalatal implants had 2.25-mm-diameter ball abutments. Mandibular implants had diameters of either 5 or 7 mm with 3.1- or 3.95-mm ball abutments, respectively (Fig 1c). All implants had the same thread configuration of a 0.6-mm pitch and a 0.1-mm width. The maxillary crestal implant had a 0.3-mm pitch depth (Fig 1b) whereas the midpalatal implant had a 0.5-mm depth (Fig 1d).

A midcrestal flap was raised for implant placement at all sites except for the midpalatal implant where a flapless technique was used. The distribution of implant lengths and diameters in the four participants is shown in Table 1.

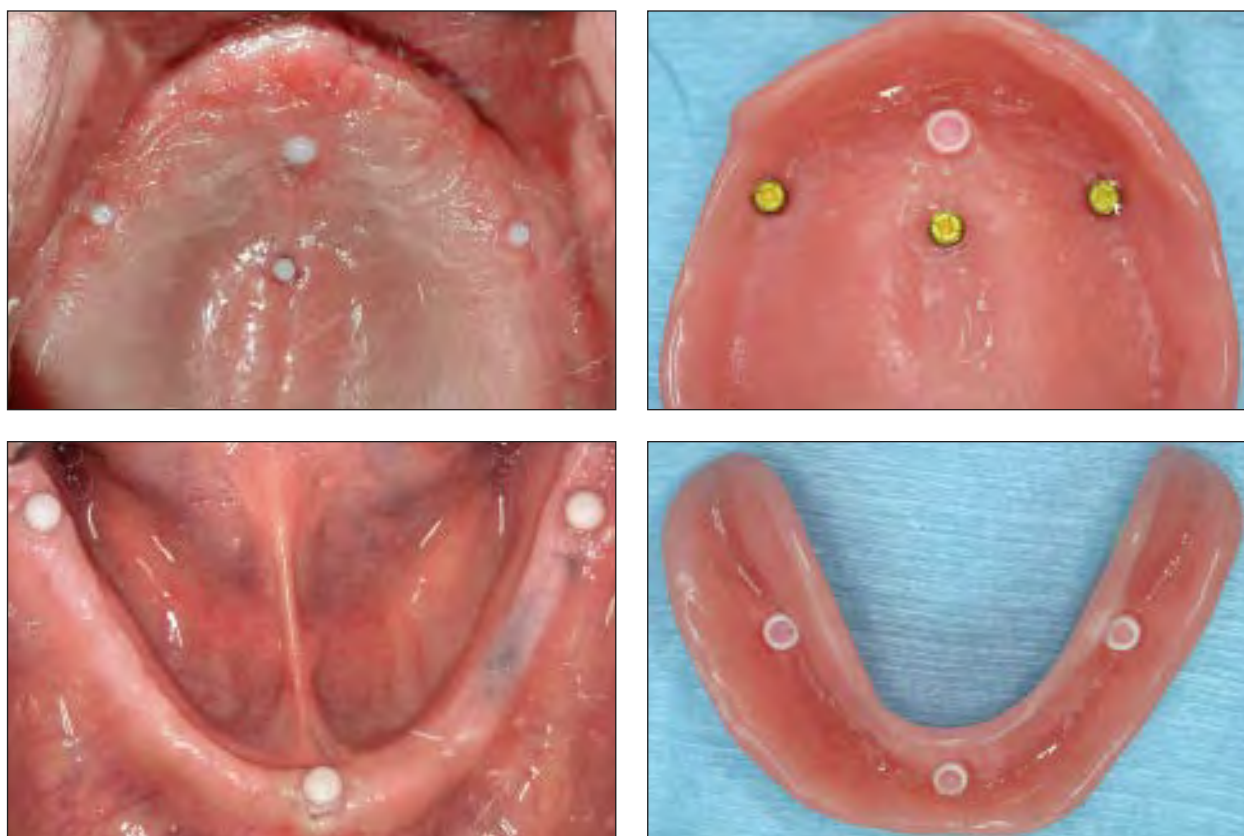
Prosthodontic Procedures

Immediately following surgery, the intaglio surfaces of the diagnostic complete dentures were relieved and relined with a tissue conditioner (Visco-gel, Dentsply). After 4 months of healing (conventional loading protocol), closed-mouth impressions were made with polyether material (Impregum Penta, 3M ESPE) for indirect relining to include custom-made matrices on the intaglio surfaces of the prostheses. The attachment systems were composed of ball abutments with different diameters and their corresponding matrices.

Table 1 Implant Diameters and Lengths Including the Size of Patrices

Participant	Maxillary overdenture				Mandibular overdenture		
	Implant site 14*	Implant site 24*	Incisive foramen	Midpalatal	Implant site 36*	Midsymphyseal	Implant site 46*
1							
Implant	3.8 × 11.5 mm	3.8 × 11.5 mm	5 × 10 mm	5 × 6 mm	5 × 8 mm	5 × 11.5 mm	5 × 8 mm
Ball	2.25 mm	2.25 mm	3.1 mm	2.25 mm	3.1 mm	3.1 mm	3.1 mm
2							
Implant	3.8 × 11.5 mm	3.8 × 11.5 mm	5 × 10 mm	5 × 6 mm	5 × 8 mm	5 × 11.5 mm	5 × 8 mm
Ball	2.25 mm	2.25 mm	3.1 mm	2.25 mm	3.1 mm	3.1 mm	3.1 mm
3							
Implant	3.8 × 11.5 mm	3.8 × 11.5 mm	7 × 9 mm	5 × 6 mm	7 × 9 mm	5 × 10 mm	7 × 9 mm
Ball	2.5 mm	2.25 mm	3.95 mm	2.25 mm	3.95 mm	3.1 mm	3.95 mm
4							
Implant	3.8 × 11.5 mm	3.8 × 11.5 mm	7 × 11 mm	5 × 6 mm	5 × 10 mm	5 × 10 mm	5 × 10 mm
Ball	2.25 mm	2.25 mm	3.95 mm	2.25 mm	3.1 mm	3.1 mm	3.1 mm

*FDI tooth-numbering system.

**Fig 2** Clinical example of one pilot study participant.

For the 2.25-mm-diameter abutments, the plastic matrices were used with a housing for the mechanical retention in the acrylic resin, while only plastic caps were employed for the larger ball abutments. The

different diameters of ball abutments used are described in Table 1. Participants were then followed for 1 year (Fig 2).

Results

A total of 28 implants were inserted: 16 were placed in the maxilla with the quadrilateral design and 12 in the mandible with the tripodal design. Two maxillary implants and two mandibular implants failed to achieve osseointegration prior to loading. One participant with the failed midpalatal implant had the incisive foramen implant placed too deeply, which meant that the attachment system could not be used. Therefore, the maxillary overdenture was retained by only two crestal implants at the premolar region. The participant with the failed incisive foramen implant declined a replacement implant, and the maxillary overdenture was retained using the remaining three implants. The participants with failed mandibular implants had them replaced successfully prior to prosthodontic rehabilitation.

At the 1-year follow-up, all implants in all four participants were surviving and the overdentures were in function without any clinical signs of wear of the matrices. No other prosthodontic maintenance was required during the 1-year follow-up period.

Discussion

The justification for using this novel prosthodontic design is the need for improved biomechanics when using one-piece zirconia implants for maxillary and mandibular overdentures. Ideal anatomical locations for implant placement were identified that would theoretically reduce fulcrum lines around which the prostheses rotate and thus minimize both residual ridge resorption and future prosthodontic maintenance. The feasibility of novel sites for zirconia implant placement and satisfactory prosthodontic treatment outcomes for maxillary and mandibular overdentures was proved via this pilot study for conducting a planned randomized controlled trial. Implant losses were attributed to design features of the prototype zirconia implants, rather than the prosthodontic protocol.

The practicality of the alternative maxillary implant sites proposed deserves comment. Currently, little evidence exists for the long-term success and survival rates of implants supporting overdentures placed in the midpalatal region; however, the encouraging results of this pilot study warrant more extensive examination of this anatomical site. Traditionally, the incisive foramen has been avoided due to concerns regarding damage to its neurovascular contents. However, this pilot study found that the use of this site did not cause any discomfort for the participants. Of greater concern was the need for the excision of hyperplastic peri-implant mucosa to expose the head of

the ball abutment of the one-piece zirconia implants. In this study, of the four implants placed in the incisive foramen, one implant failed and another became unfeasible due to deep placement and hyperplastic peri-implant mucosa. Because of the prosthodontic rehabilitation difficulties of using the incisive canal region, a modified quadrilateral design where the incisive foramen site is replaced by an off-centered anterior crestal implant is proposed. This design would still retain the biomechanically favorable distribution of forces seen in the initial design. Despite this, the preliminary findings of this study suggest that the incisive foramen can be used as an alternative implant site for the rehabilitation of the edentulous maxilla in selected cases when inadequate bone exists in the anterior maxillary alveolar ridge. For the mandibular overdentures, the anticipated biomechanics could be influential on prosthodontic treatment outcomes and maintenance. The tripodal design in the mandible resulted in very stable overdentures for the pilot participants.

To accommodate the attachment systems for the palatal and incisive foramen implants, the palate of the maxillary overdenture had to be thickened. This did not adversely influence speech as subjectively determined by the participants. This could be explained by an increase in closest speaking space that occurs with the thickening palatal vault of complete dentures. It has been shown that the regularity of the closest speaking space obtained 90 days after thickening the palatal vault of maxillary complete dentures can be interpreted as a sign of patients' adaptation to the prosthesis.⁸

The limitations of this pilot study are acknowledged. They relate to the number of variables to properly assess these novel designs. It is recognized that difficulties with prosthodontic rehabilitation are encountered when placing a one-piece implant in the incisive foramen, especially in the case of deep placement, in addition to the thickness of oral mucosa that could hinder engagement of the attachment systems. As a result, there is a need for modifications to address some of the issues identified in this study.

Conclusions

The present study constitutes proof-of-principle for prosthodontic perspectives of a novel design using one-piece zirconia implants to support maxillary and mandibular implant overdentures. Outcomes indicate caution with regard to these proposed alternative implant sites; therefore, some modifications to the initial quadrilateral design are proposed. Further investigation of the suitability of one-piece zirconia implants

is warranted before accepting these novel prosthodontic designs for routine clinical practice. This pilot study provides evidence for conducting a planned randomized controlled trial.

Acknowledgments

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Literature Abstract

Association between childhood obesity and dental caries

This retrospective study investigated the association between body mass index (BMI) percentile and dental caries for pediatric dental patients. For 3 years, all 6- to 9-year-old children who were seen for a new patient examination and who had at least one recall examination were included in this study. During each initial and recall visit, the parameters recorded were decayed permanent teeth (DT), decayed primary teeth (dt), plaque score, gingival score, height and weight from which the BMI percentile was categorized: underweight/healthy weight (UH), overweight (OW), and obese (OB). Of the 230 subjects included at the initial examination, about 13% were OB, 15% were OW, and 72% were UH, while approximately 12% had permanent caries and 46% had primary caries. There was no significant difference in the presence of caries in permanent teeth at the initial examination between BMI groups ($P = .41$). For primary tooth caries, OW and OB children had less caries than UH children. ($P = .04$) There was no significant difference in the presence of new carious lesions at recall examinations in primary teeth ($P = .35$) and permanent teeth ($P = .96$) between BMI groups. The authors concluded that less obese and overweight children initially presented with primary tooth decay than underweight/healthy weight children.

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