Implant-supported titanium prostheses following augmentation procedures: A clinical report

C Knabe,* B Hoffmeister†

Abstract
Background: This report describes a novel technique for fabricating retrievable implant-supported titanium (Ti) prostheses in patients requiring a comprehensive treatment plan involving the combined efforts of maxillofacial surgery and implant prosthodontics.

Methods: Following bone graft reconstructive surgery and implant placement prosthetic treatment was initiated by inserting ITI-Octa abutments. An impression was made, and a framework was fabricated by fusing Ti-cast frameworks to prefabricated titanium copings by laser-welding. This was followed by veneering or fabrication of a removable denture with Ti metal re-inforcement.

Results: Favourable clinical results have been achieved using these screw-retained Ti implant-supported restorations for patients treated with reconstructive bone graft-surgery, with clinical observation periods ranging from three to four years.

Conclusions: The present observations suggest that these screw-retained implant-supported Ti prostheses may be a meaningful contribution to implant prosthodontics, facilitating retrievable restorations of optimum biocompatibility, good marginal precision and with a good esthetic result. However, controlled clinical studies are needed to establish the long-term serviceability of these Ti restorations.

Key words: Implants, titanium restorations, bone graft reconstructive surgery, veneering systems, laser-welding.

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INTRODUCTION
In order to avoid galvanic effects, a need has emerged to use the same metal or dental alloy for all restorations installed in the oral cavity.1 In this respect, and because of its excellent corrosion resistance, biocompatibility and light weight, titanium (Ti) appears to be the material of choice for implant restorations. However, prosthodontic application of Ti first required the mastery of considerable technical problems with respect to casting technology and veneering systems.1 When Ti was introduced for use in ceramo-metal systems, suitable low-fusing porcelains had to be developed. In recent years considerable efforts have been undertaken to improve these veneering systems in order to achieve better bonding between ceramic and titanium. Since various in vitro studies have demonstrated that sufficient bonding strength can be achieved with several of these improved veneering systems,2-4 clinical use is justified. However, data from clinical studies are still limited. Although several clinical studies have been presented for ceramic veneered machined titanium restorations,9-16 there are very few studies dealing with the clinical performance of ceramo-metal cast restorations.17 Furthermore, often first generation veneering systems were used in these studies. More recent studies seem to indicate a higher survival probability for the new ceramic materials.11,13 On the basis of these developments we commenced the construction of implant-supported ceramo-metal Ti prostheses on a regular basis seven years ago.

Specific aspects had to be considered, when fabricating implant superstructures from Ti by casting, because the prefabricated gold-alloy copings for the casting-on technique as offered by many implant systems could not be applied, since Ti does not bond to these copings. It has been possible to avoid these difficulties by using the ITI-cone abutments, because the same technical procedures can be applied as for the fabrication of natural tooth supported crown and bridgework, thus resulting in cemented restorations.18-20 Recent improvements in implant systems21 and the laser welding technique22 have rendered it possible to fuse prefabricated titanium copings to Ti-cast frameworks, thus obtaining screw-retained Ti restorations with superior marginal precision.22 As a result of these developments patients who require comprehensive treatments involving the combined efforts of maxillofacial surgery and prosthodontics have benefited from implant-supported
Ti-cast restorations in our department. In these patients we have constructed cemented or screw-retained fixed ceramo-metal restorations as well as bar-retained removable Ti overdentures or restorations featuring telescope crowns. This report describes a novel technique for fabricating screw-retained implant-supported Ti prostheses and demonstrates the use of these restorations in patients requiring a comprehensive treatment plan involving bone graft reconstructive surgery.

MATERIALS AND METHODS

Augmentation procedures

Augmentation procedures used for reconstruction of the edentulous atrophic maxilla included the use of onlay iliac crest bone grafts or application of Le Fort I osteotomy in conjunction with an interpositional iliac crest bone graft and mostly immediate implant placement using ITI-Bonefit screw implants.18 Whenever possible, a surgical template was employed for implant placement. In the mandible, alveolar ridge augmentation was performed using onlay bone grafts in most cases. Due to the combination with bone grafts implants were placed in a submerged manner.23

Construction of frameworks

After completion of the healing period, implants were exposed and prosthetic treatment initiated. For screw-retained restorations ITI-Octa abutments were inserted. Impression taking, interocclusal records and mounting of the master casts were performed according to standard procedures. For fabrication of the frameworks, either prefabricated titanium copings for transocclusal screw-retained restorations or the ITI-Octa TS titanium blank copings for transversal screw-retained superstructures were used (Fig 1). These were mounted on the implant/abutment analogues. The blank copings were ground to the desired shape, if needed, and then the framework was waxed-up. The wax-pattern of the framework was invested without the copings. Titanium castings were fabricated using the Castmatic casting machine (Dentaurum Inc, Pforzheim, Germany). The Ti copings and the framework were then fixed into place with fully combustible resin and ready for try-in (Fig 2). Try-in of the framework was important to ensure complete seating without stress. After try-in the frameworks were fused to the Ti copings by laser welding. This was followed by veneering or fabrication of the removable denture with Ti metal re-inforcement. For veneering the low-fusing Vita Titanium Porcelain (Vita Inc, Bad Säckingen, Germany) was used.

Clinical follow-up

Follow-up examinations were carried out every six months. In addition to the standard parameters recorded for implant patients,18,19 specific attention was paid to the examination of the veneers in these patients. The veneers were inspected for fractures or cracks and changes in surface texture and colour.17

CASE REPORTS

Case 1

A 42-year-old-man required bone graft reconstructive surgery for the extensive bony defects caused by the removal of a squamous cell carcinoma in the anterior mandible and subsequent irradiation therapy. For reconstruction of the bony defect cortico-cancellous grafts were harvested from the iliac crest.
The secondary surgery, at six months, involved removal of the osteosynthesis plates and placement of ITI-Bonefit screw implants as shown in Fig 3. Due to the increased risk of placing implants in irradiated bone\textsuperscript{24-28} seven implants were inserted. After completion of the healing period the implants were exposed and Octa-abutments and Octa TS-fixation posts were installed (Fig 4). Impression taking, interocclusal records and mounting of the master casts followed. For try-in the titanium frameworks and the Octa TS titanium copings for transversal screw-retention were fixed into place on the master cast with combustible resin. After try-in, the frameworks were fused to the Ti copings by laser welding and veneering work was carried out (Fig 5). This was followed by final placement of the restorations (Fig 6-8). The patient has been monitored for three years.

Case 2
A 59-year-old-woman presented for prosthetic treatment after rehabilitation of her atrophic maxilla by alveolar ridge augmentation using an onlay iliac crest bone graft and placement of six implants. After completion of the healing period the implants were exposed and Octa abutments installed (Fig 9). The Octa TS Ti copings were manually contoured by a dental technician. For try-in the Ti framework for a full-arch bridge and the Octa TS Ti copings for transversal screw-retention were fixed into place with combustible resin (Fig 2, 10). After try-in, the framework was fused to the titanium copings by laser welding. A second try-in followed and the veneering work was carried out. Final placement of the prosthesis followed (Fig 11). Follow-up time for this case was three years.

Case 3
A 56-year-old-man presented for prosthetic treatment of his maxilla after reconstructive surgery for complex maxillofacial injuries as a result of missile wounds. In the mandible, a conventional implant-
supported bar-retained overdenture was placed elsewhere a number of years prior. These complex injuries required extensive bone and soft tissue reconstruction. Multiple reconstructive operative procedures were performed including bone graft placement in the maxilla and insertion of six implants. After a healing period of six months, implants were exposed and Octa abutment connection was carried out. The surgical procedures caused a loss of labial tissue and subsequent scar contraction. This severely restricted opening the mouth. Consequently, a two-part customized impression tray was used. In this case, after try-in, Ti copings for transocclusal screw retention and a cast bar framework splinting all six implants were welded together (Fig 12). This was followed by fabrication of the corresponding metal re-inforced partial denture (Fig 13, 14). The prefabricated Ti bar sleeves were fused to the metal base of the denture by laser welding. Due to the hard and soft tissue deficiencies present a removable implant-supported prosthesis was chosen in order to satisfactorily restore the facial contours. A labial flange simulating the gingivae filled in the alveolar ridge defects and provided adequate support for the upper lip. Thus, sufficient labial and buccal fullness was obtained by proper contouring of the labial and buccal denture flanges. Hence, using a removable denture resulted in better esthetics than when a fixed implant supported prosthesis would have been used. Due to the presence of a bar-retained overdenture in the mandible a balanced occlusion was chosen. Final placement of this maxillary implant supported prosthesis followed (Fig 12). Observation time for this case was three years.

RESULTS

Favourable clinical results have been achieved using screw-retained Ti implant-supported restorations for patients treated with reconstructive bone graft-surgery, with clinical observation periods ranging from three to four years. The light weight of the fixed multi-unit restorations and the removable metal-re-inforced Ti dentures was considered advantageous in these patients requiring comprehensive implant prosthodontics. Neither complications with regard to the laser-welded components nor screw-fractures were noted. Furthermore, complication-free serviceability of the ceramo-metal Ti prostheses used in these patients and in implant patients without bone graft augmentation procedures was observed for periods ranging from three to six years in nearly all cases. A total of 133 veneered units were followed in 14 patients. Of these 83 were part of implant-supported restorations and 50 of restorations with natural teeth serving as abutments. Of the total 133 veneered units, no obvious changes were noted for the texture and colour in the ceramics.
Fracture occurred in the pontic area in two veneers at a few weeks or one year after the placement of these implant-supported three-unit fixed prostheses. Currently, a clinical study is being conducted dealing with the longevity of new ceramic materials.

**DISCUSSION**

The resiliency of the periodontal membrane encountered in the natural dentition is absent in the case of osseointegrated dental implants. Therefore, the importance of a passive fit between implant superstructures and the implant fixtures has been emphasized in the dental literature\(^{29-32}\) in order to prevent transformation of stress from the superstructure to the implant and surrounding bone.

Distortion of the framework during casting has been cited as the main cause of misfit in implant frameworks.\(^{30,31-35}\) The tightening of an inaccurate framework to the implant abutments will transmit stresses to the bone implant interface.\(^{36,37}\) Several postcasting techniques to correct framework distortion have been described. Among them are cutting and soldering or casting in separate units and laser welding,\(^{36,38}\) which is applicable for Ti frameworks. A prerequisite for laser welding is that the gap between the surfaces to be assembled must be narrow and as parallel as possible.\(^{39}\) Marginal precision\(^{1,21-23}\) and galvanic effects\(^{1}\) are also important factors in the precise approach to the treatment planning of implant supported-prostheses. The use of prefabricated Ti copings for implant superstructures facilitates restorations of superior marginal precision.\(^{21,23}\) A passive seating of the prosthetic elements can be achieved in a more reliable manner by fusing prefabricated titanium copings to Ti-cast frameworks by laser welding after try-in for clinical fit in the oral cavity.\(^{39}\) The application of prefabricated Ti copings and Ti castings allows the restorative team to fabricate implant prostheses in pure Ti within completely biocompatible parameters avoiding chemical reactions caused by galvanic corrosion. Moreover, the use of ITI-Octa Ti copings for transversal screw-retained superstructures results in retrievable restorations with good esthetics.

While favourable clinical results have been achieved in the present report, close collaboration between dentist and an experienced technician who is familiar with the requirements of casting, welding and veneering Ti for dental prosthesis is a prerequisite. With respect to veneering, specific attention has to be paid to proper extension of the framework in the area of the pontics. The fractures which were encountered in two cases in the areas of the pontic had to be attributed to the framework design. In case 1 (third and fourth quadrant) small unit restorations were preferred to avoid extensive splinting of abutments in the mandible, because torsions and deformations of the mandible cannot be compensated by osseointegrated implants.\(^{40}\) Our findings regarding clinical performance of the veneered Ti restorations are in accordance with a report by Walter\(^{41}\) who stated that there is a tendency of decreasing clinical failure rates with newer ceramic materials and firing techniques. He also emphasized the importance of following the often forgotten classical design rules of metal-ceramic restorations.

The present observations suggest that osseointegrated Ti prostheses – screw-retained and cemented fixed ceramo-metal restorations as well as removable implant-supported dentures – could form a valuable part of restorative therapy following augmentation procedures. Furthermore, these Ti prostheses may be a meaningful contribution to implant prosthodontics, facilitating restorations of optimum biocompatibility. However, more controlled clinical studies are needed to establish the long-term serviceability of these titanium restorations.

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**REFERENCES**


Address for correspondence/reprints:
Dr Christine Knabe
Department of Experimental Dentistry
University Hospital Benjamin Franklin
Free University of Berlin
Aßmannshausen Str. 4-6
14197 Berlin, Germany
Email: Christine.knabe@medizin.fu-berlin.de