Immediate Loading of Single-Tooth Implants in the Posterior Region

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Purpose: *The aim of this study was to evaluate the clinical response and safety of immediately loaded single-tooth implants placed in the posterior region of the maxilla and mandible.* ***Materials and Methods:*** *Single-tooth implants were placed in healed extraction sites in 20 adult patients. Temporary prefabricated acrylic resin crowns were prepared and adjusted. The crown occlusion was adjusted to obtain minimal contacts in maximum intercuspation. After 6 weeks a ceramometal or all-ceramic crown was cemented. Radiographic and clinical examinations were made at baseline and at 3, 6, and 12 months. Cortical bone response and peri-implant mucosal responses were evaluated.* ***Results:*** *The marginal bone level at the time of implant placement was preserved. The mean change in marginal bone level was 0.01 mm at 12 months. The mean Periotest value after 360 days was −4. The peri-implant mucosal adaptation to the anatomic form of the provisional crown resulted in a natural esthetic outcome, and a gain in papilla length was observed. One implant failure was recorded because of provisional luting cement impaction.* ***Discussion:*** *Clinical research has shown that immediate loading is a possible treatment modality. The immediate functional loading of implants placed in this study resulted in bone adaptation to loading. A satisfactory success rate with positive tissue responses was achieved.* ***Conclusions:*** *The results of this limited investigation indicated that immediate loading of unsplinted single-tooth implants in the posterior region may be a viable treatment option with an esthetic outcome.* Int J Oral Maxillofac Implants 2005;20:61–68

Key words: *dental implants, emergence profile, esthetics, immediate loading, osseointegration*

In implant dentistry a stress-free healing period is generally accepted as a prerequisite to achieve bone apposition and implant integration without the interposition of fibrous scar tissue. Traditional guidelines for attaining osseointegration include up to 6 months of nonloaded healing time. This concept was introduced by Brånemark and coworkers in 1977.[1] As a result of refined surgical protocols, an optimized implant design, and other surface characteristics, a shortened healing period is currently possible. Immediate loading of implants that are cross-arch-stabilized with either a rigid bar or a fixed provisional prosthesis have been reported by several authors.[2–5] The success rate of this treatment is comparable to that for conventionally loaded implants.[6,7]

Unlike previous investigations of immediate or early loading, this study presents a single-tooth implant protocol in posterior sites with unsplinted implants. The aim of this study was to evaluate the clinical response and the predictability of immediately loaded single-tooth implants. Since dental implants must withstand relatively high forces and loading moments in function in the posterior,[8] a better understanding of in vivo bone response to immediate loading of single-tooth implants is needed.

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MATERIALS AND METHODS

This clinical trial was conducted as an open, prospective, interdisciplinary trial at the Department of Dental Prosthodontics, the Department of Oral Surgery, and the Department of Preclinical Education and Dental Research of the Rheinische Friedrich-Wilhelms University in Bonn, Germany. All recruitment and subsequent treatment was conducted under the auspices of an informed consent document. This study was performed in accordance with the principles stated in the Declaration of Helsinki.[9] The ethics committee of the Rheinische Friedrich-Wilhelms University approved the study.

Initially the patients were screened according to the following inclusion criteria:

The patient had to be at least 18 years old, and his or her general systemic health could not be compromised. The patient had to be free of periodontal disease; successful periodontal treatment had to have been completed. The patient had to require single-tooth replacement in the posterior region and have at least 1 antagonist tooth in the posterior region of the maxillary and mandibular arches. The patient had to have sufficient hard tissue at the implantation site to allow the use of an 11-mm-long implants with a diameter of at least 3.5 mm (A11) or 9.5-mm-long implants with a diameter of 5.5 mm (C8). The patient had to be willing and able to complete the study.

Patients who were pregnant or lactating, addicted to alcohol or drugs, or had a daily smoking habit, a habit of severe bruxism, or uncontrolled periodontal disease were excluded from the study. Furthermore, patients with any disease or condition or on any medication that might compromise healing or osseointegration were excluded.

Patients conforming to the inclusion criteria and willing to provide informed consent were enrolled. Selected patient characteristics were recorded, including the general medical history, medication, and oral status. Fifteen female and 5 male patients were recruited and treated. The age of the patients ranged from 21 to 60 years, with a mean age of 33 years.

In the present study, the Ankylos implant system (Friadent, Mannheim, Germany) was used. The surface of the implant is sandblasted, with a 2-mm smooth transmucosal collar. The implant has a progressive thread design that influences load distribution. The loading forces increase in an apical direction.

Preimplant documentation was obtained for treatment planning purposes. Radiographs—panoramic and periapical with a customized right-angle holder—were obtained to evaluate the alveolar ridge. Determination of the mucosal thickness was performed by noninvasive ultrasonic measurements (SDM/Austenal-Krupp, Chicago, IL) at the site of implantation. On a split-die cast, the mucosal thickness and bone quantity at the implantation site were analyzed. A diagnostic waxup of the failing natural tooth and a clear acrylic resin surgical drill guide were prepared to facilitate correct implant placement.

Implant length, implant diameter, and abutment length were recorded, as well as whether the thread tap was prepared partly or completely. The Periotest electronic device (Siemens, Munich, Germany) was used to monitor oral implant stability and detect subclinical mobility. All implants presented in this study were placed in sites without bone augmentation or any bone expansion surgical procedure. The implants were placed in completely or partially bone-regenerated sockets.

Surgical Procedure

The surgeries in this study were performed by 1 surgeon. Local anesthesia was obtained with Ultracain D-S 4% (Aventis Pharma Deutschland, Frankfurt am Main, Germany). A crestal incision with sulcular releasing incisions at the adjacent teeth was usually performed. Buccal and lingual full-thickness flaps were then elevated to expose the underlying ridge (Fig 1a). Another possibility was a full-thickness flap, which was reflected only buccally. The first curved mesiodistal incision did not extend too far on the lingual side. At the mesial or distal side of the adjacent teeth, a sulcular incision was made to the buccal (Fig 1b). This flap design maintained the volume and position of the papillae.

The bone was flattened before implantation, and a surgical drill guide was used for the precise placement of the pilot drill. The appropriate position of the implant neck in both the vertical and horizontal dimension was decisive. The implant neck was positioned at the crestal bone level or slightly submerged.

After pilot drill application, the implant site was prepared with the corresponding size of parallel drill. The thread tap, the last instrument used prior to implant placement, was consequently hand driven. In some cases, depending on the bone quality, the thread tap was only prepared partly. The implant was placed as a self-tapping thread if possible. Using this technique, an optimal combination of simple, precise, and easy implant placement and good primary stability could be achieved (Fig 2a).

Immediately after implant placement the implant post was connected (Fig 2b). A standard solid abutment was attached to the implant using a torque controller with a force of 25 Ncm. Once the implant post was connected, the flap was replaced in its initial position and sutured with nonresorbable thread (4-0 or 5-0). The sutures were removed after 7 days.

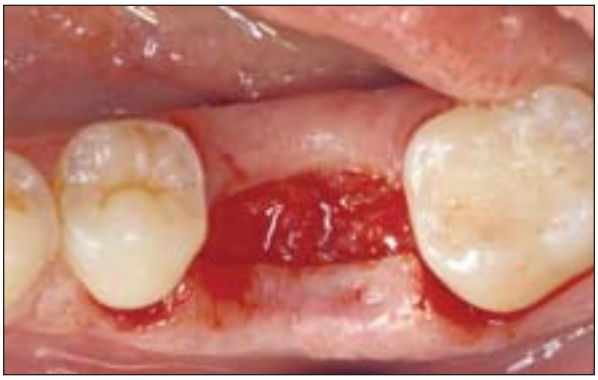

Fig 1a Buccal and lingual full-thickness flaps after a crestal incision.

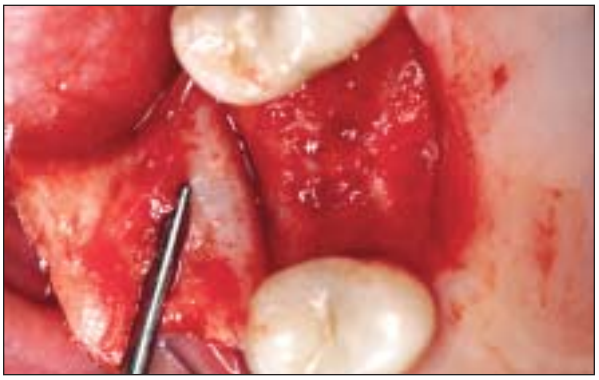

Fig 1b Buccal full-thickness flap with a mesiodistal incision on the lingual side.

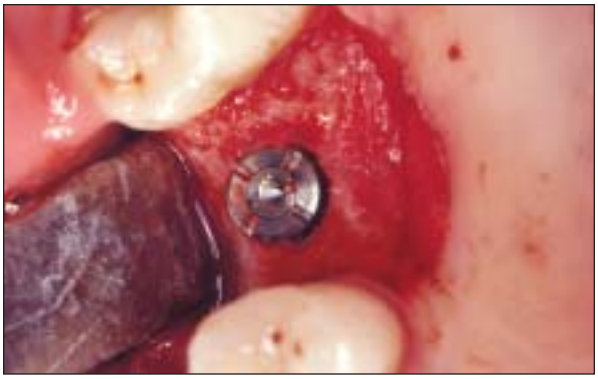

Fig 2a Surgical site immediately after implant placement.

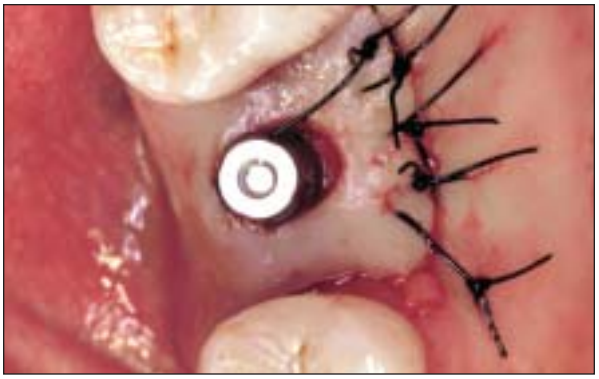

Fig 2b Connection of a standard solid abutment immediately after implant placement.

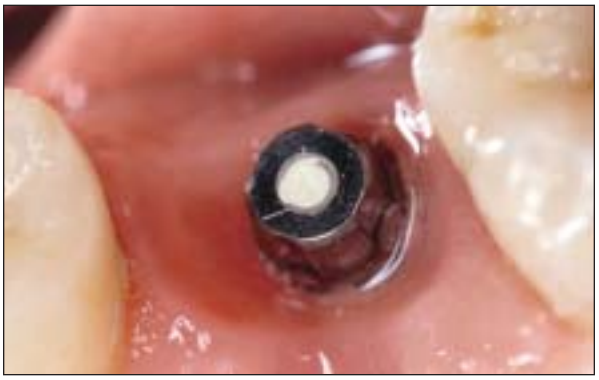

Fig 2c Guided soft tissue healing with the provisional restoration removed.

Prosthetic Procedure

The prosthetic procedures were performed by 1 prosthodontist. After the surgical intervention the prefabricated temporary acrylic resin crown was relined with an autopolymerizing acrylic resin (Cron-Dur Plus; BonaDent, Frankfurt am Main, Germany) and placed. After the occurrence of provisional zinc oxide-eugenol cement (TempBond, Kerr Dental Products, Romulus, MI) impaction while placing the first 7 temporary crowns, the following 13 crowns were screwed onto the abutment. Compared to natural teeth, the temporary restoration had a narrower occlusal surface without any contacts in functional occlusion. In maximum intercuspation, only point occlusal contacts were provided. The interproximal contacts were designed as broader contact areas to distribute the forces of mastication and provide support. Depending on the gingival thickness, the crown margin was located 0.5 to 1 mm below the gingiva.

Evaluations during the provisional crown treatment phase were made after 1 day for wound control, after 7 days for the removal of the sutures and final contouring of the soft tissue, after 2 to 3 weeks for wound healing and observation of the emergence profile, and after 4 or 5 weeks for the final impression. Continuous Periotest measurements were made at every recall session to monitor implant stability.

With the provisional restoration, guided soft tissue healing was performed to achieve an esthetic soft tissue contour around the provisional and definitive restorations. The overshaped provisional crown

applied pressure to the soft tissue and maintained the proper scallop of the gingiva. To prevent trauma to the healing tissue, the polished temporary crown initially established only slight pressure on the soft tissue. After 1 week, the temporary crown was removed to permit the adding of composite to the proximal subgingival areas. This compressed the soft tissue and the interdental papillae, facilitating slight coronal hyperplasia of the gingival tissue (Fig 2c). The buccal emergence profile of the provisional crown was carefully contoured to prevent excess buccal pressure. The aim was to have a harmonious course of the gingival margin and the presence of interdental papillae. After 4 or 5 additional weeks, healing had progressed and the final prosthetic stage was initiated. Impressions were made with transfer impression copings for the fabrication of the definitive restoration. Silicon or polyether materials were used for impressions. Modifications of the solid abutment could be made intraorally with an appropriate bur under copious water spray. It was imperative that a soft tissue master cast be fabricated to change the contour of the soft tissue. Jaw relationships were recorded by means of a wax or composite medium in maximum intercuspation. The stone casts were mounted in a semiadjustable articulator.

After 6 weeks the temporary crown was removed. If a standard abutment could not be used, a special balance posterior abutment from the system was connected to the implant at the end of the healing phase. In this case the abutment position was transferred to the dental laboratory with an overcast, and the dental technician selected the appropriate balance abutment. Balance abutments are suitable for esthetically demanding restorations.

The definitive restoration was fabricated as a ceramometal crown. Alternatives were galvanoformed crowns (Gramm, Tiefenbronn-Muhlhausen, Germany) with ceramic veneers or full-ceramic crowns. The morphology of the occlusal surfaces was similar to that of natural teeth with occlusal contact in maximum intercuspation and physiologic cusp inclination. The occlusal concept for implants with high mechanical strength required that the following requirements be met by the definitive restoration: The occlusal surfaces had to be of normal size, with contacts in static occlusion and maximum intercuspation with central tripodization (where molars were being replaced) and/or marginal ridge contacts (where premolars were being replaced). Physiologic cusp inclination was required, and there could be no interferences in functional occlusion. The crown restorations were cemented. Temporary cement in the ceramometal crowns allowed the use of a fixed-removable suprastructure.

Periotest measurement, an occlusal check, and verification of the presence or absence of inflammation of the peri-implant mucosa were performed 2, 3, 4, 6, and 12 months after cementation of the definitive crown. A classification system for the papillary height was used.[10] Complications and adverse events, if present, were documented.

The definitive restoration was removed for performance of the Periotest. Two measurements per implant were made at each appointment. If there was a discrepancy between the 2 measurements, at least 1 additional measurement was made. The 2 identical values were recorded. Periotest values of < 0 indicated that osseointegration had been achieved.[11] Values higher than 9 denoted the absence of osseointegration.[12]

The marginal bone level after implant placement and 3, 6, and 12 months postoperatively was compared using periapical radiographs with a customized right-angle holder. After scanning the radiographs, the location of cortical bone was measured with an image analysis program (Image-Pro Plus Version 4.5, Media Cybernetics, Silver Spring, MD) at the implant reference point (mesial and distal aspects of the implant shoulder). The distance between the reference point and the most coronal implant-bone contact point was measured and compared between different time intervals. The value was positive when the implant-bone contact was more coronal than the reference point.

RESULTS

Twenty patients have been recruited and treated since June 2001. Fifteen surgical sites had type 2 bone, 4 had type 3 bone, and 1 had type 1 bone according to the definition of Lekholm and Zarb.[13] All patients were restored with definitive crowns. Eighteen ceramometal crowns, 1 galvanoformed crown, and 1 full-ceramic crown have been used.

All the implants were placed and immediately loaded with a provisional crown. Eleven implants replaced a first molar and 9 implants were placed in the premolar region. Nine implants were placed in the maxilla and 11 in the mandible. The implant length ranged from 9.5 mm to 14 mm, with diameters of 5.5 mm (n = 6), 4.5 mm (n = 6), and 3.5 mm (n = 8).

The immediately loaded implants successfully osseointegrated. There was only minor bone loss according to the radiographic examination (Figs 3a to 3c). At baseline, the average distance (mean ± SD) from the implant reference point to the marginal bone level was 0.29 ± 0.72 mm in the maxilla and 0.74 mm ± 0.74 mm in the mandible. The mean

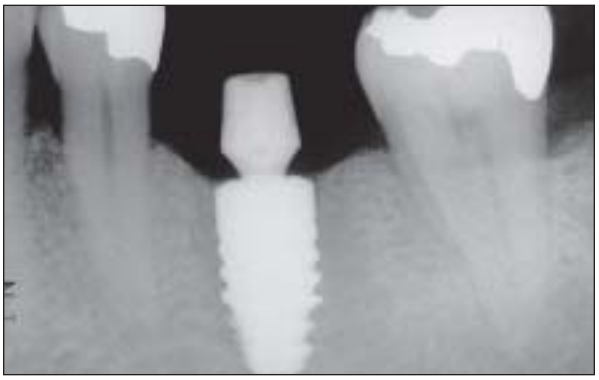

Fig 3a Radiographic examination of cortical bone position at placement.

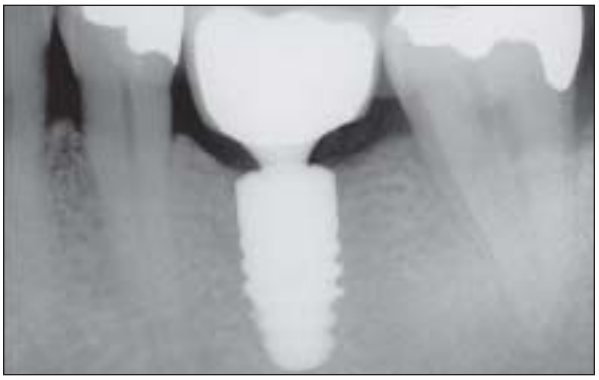

Fig 3b Radiographic examination of cortical bone position after 6 months.

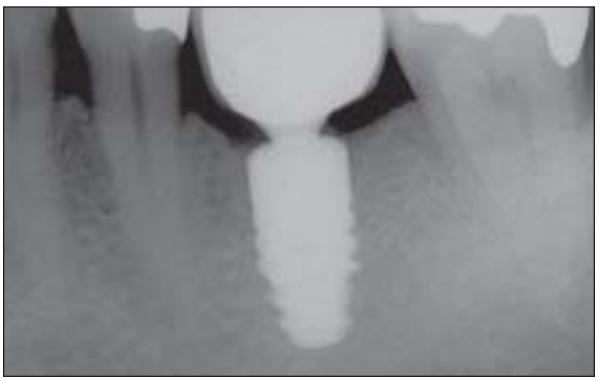

Fig 3c Radiographic examination of cortical bone position after 12 months.

marginal bone level changes in the maxilla were –0.02 mm ± 0.48 mm, –0.06 mm ± 0.50 mm, and 0 mm ± 0.59 mm at the 3-, 6-, and 12-month follow-ups, respectively. In the mandible, the mean marginal bone level changes were –0.22 ± 0.39 mm, –0.22 ± 0.42 mm, and 0.03 ± 0.36 mm for the same follow-up periods, respectively. Little change was seen in the relationship between cortical bone level and the implant reference point. At 12 months postloading, marginal bone change ranged from –1.21 mm to +1.01 mm. The compact cortical and cancellous bone were in close contact with the implant surface without any gaps up to the implant shoulder.

Cortical bone loss after 1 year was also measured. There were 10 implants with 0 to 0.5 mm of horizontal cortical bone loss and 9 implants with 0.5 to 1 mm. No vertical bone defects could be detected. Most important, 10 of the implants showed at least 1 measurement with a gain in cortical bone height from 0.06 to 1.01 mm.

There were only minor differences in Periotest measurements. The recorded Periotest values ranged between 3 and –7. After 30 days only values of ≤ 0 were recorded. The mean Periotest value after 180 and 360 days was –4. In 11 patients the Periotest measurements presented only differences of 1 value during all recall sessions. The greatest change observed in a patient was an increase of 9 values in the first 3 weeks (Figs 4a and 4b).

Plaque accumulation at the implant abutments was low. Initial slight red coloring of the peri-implant mucosa in the early healing process and newly formed soft tissue decreased. No inflammatory response was seen. The provisionalization process established an esthetic gingival profile with a gain in interdental papilla height. The mucosal aspect of each implant restoration was stable. The peri-implant mucosal adaptation to anatomic form and the support of the papilla at every at every examination resulted in a natural esthetic outcome. A gain in interdental papilla was observed in 16 patients after 1 year.

Eighteen implants were restored with standard abutments and 2 implants with a balance abutment. None of the abutments loosened during the provisional or definitive restoration phases.

During the first 12 months some adverse events were identified. One implant failure and 1 incident of peri-implantitis were caused by temporary cement retained on the implant surface. The infection was treated by cleaning the implant surface, and bone augmentation was performed using Bio-Oss (Geistlich Pharma, Wolhusen, Switzerland) and an exclusion membrane (Bio-Gide; Geistlich Pharma). After the provisional restoration was screwed onto the abutment, no further adverse events were identified. One galvanoformed crown fractured after 2 weeks. A new ceramometal crown replaced the galvanoformed crown. Two fractures and loosening of provisional crowns were reported.

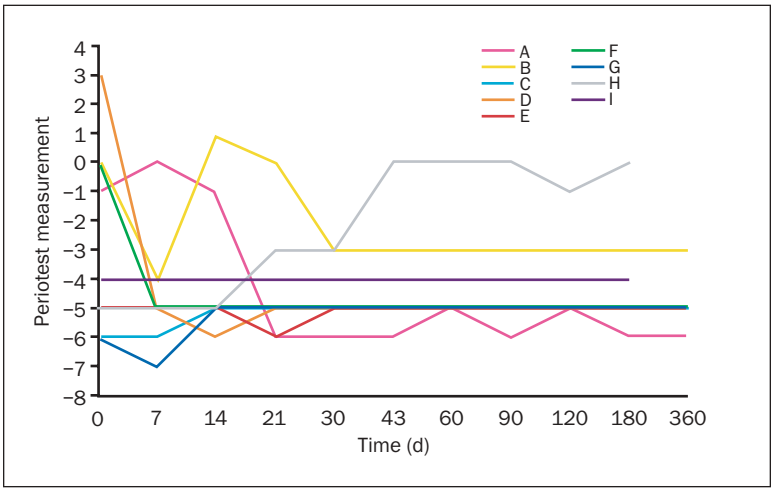

Fig 4a Periotest measurements of mandibular implants.

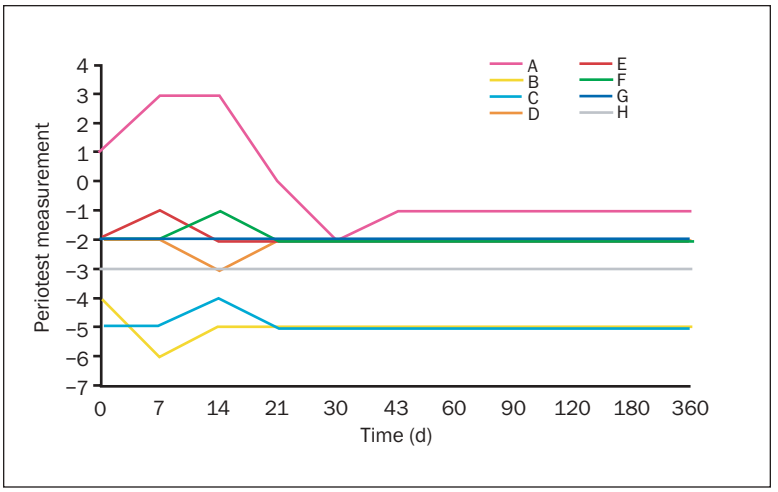

Fig 4b Periotest measurements of maxillary implants.

DISCUSSION

The rapid loading of implants after a nonfunctional period has been reported in various studies to result in radiographic evidence of horizontal and vertical cortical bone loss down to the first thread of the implants.[6,14] For implants that have healed for several weeks or months before being loaded, data support the hypothesis that interfacial overload occurs if the strains of the rapid loading are excessive in interfacial bone.[8,15] Cortical bone adaptation occurs within the first 6 months following implant placement, with no additional significant adaptation for up to 2 years of follow-up.[16] In the present study the marginal bone level at the time of implant placement was preserved over the course of a year. Immediate functional loading of primarily stable implants with mechanical forces caused by tongue or lip pressure together with masticatory forces may result in early bone adaptation. The design of the implant could also account for the minimal cortical bone loss. The progressive thread design is intended to result in high primary stability and seems to be advantageous for areas with increased occlusal forces. Moreover, the conical seal design of the implant-abutment connection of the Ankylos implant has no microgap between the implant and abutment. Thus, the cortical bone is not influenced by microgap problems and can grow over the implant shoulder.

This cortical bone response may be responsible for support of the peri-implant mucosa. Soft tissue dimension is generally limited to approximately 5 mm above the cortical bone.[17] The possible loss of up to 2 mm of bone in the adaptation phase, followed by additional bone loss in the first year after loading, can limit the ability to maintain interdental papillae.[18] The natural papilla form demonstrated in this study may be related to the observed bone maintenance.

It is often difficult to recreate the interproximal papillae and gingival profile after implant surgery. The loss of gingival embrasure form will cause interproximal tissue collapse. A key to maintaining the interproximal papillae and gingival margin is the use

of a provisional crown. The provisional restoration can provide an important role in the molding, contouring, and healing of the soft tissue. Peri-implant mucosal adaptation to an anatomic form and the support of the papilla at each time of treatment usually results in a natural esthetic outcome. The esthetic value of implant-supported single-tooth restorations is dependent on soft tissue responses to therapy.

When an unsplinted single-tooth implant is immediately loaded, the implant-abutment connection must be stable and readily reversible. The Ankylos implant system uses an implant-abutment connection with a conical seal design that did not loosen in this study. This stability has also been noted for other implant systems with conical connections[19] and has been reported in clinical studies.[18,20] The literature indicates that certain implant-abutment connections may have an increased risk of screw loosening and mechanical complications. Most implant systems rely on screws to connect vertically stacked components, so that a prosthesis can be directly or indirectly joined to the top of the implant body. One of the most commonly reported complications is the loosening of individual prosthetic components relative to each other and to the implant body, especially in single-tooth restorations. Ekefeld et al reported problems with loose superstructures in 43% of single-tooth restorations with Brånemark System implants.[21] This complication has also been reported by others.[22,23] Screw loosening has occurred primarily in the single-implant loaded situation, where rotational aspects[24,25] are especially applicable. The manufacturers of implant systems have generally addressed this problem, but Cantwell and Hobkirk demonstrated that even new prosthetic gold screws can suffer significant loss of preload following placement.[26]

Single-implant situations in the posterior region may have a higher susceptibility to bending overload. Increasing the implant diameter can be an effective way of increasing clinically relevant implant strength. Wider implants can be used when possible for improved strength within the implant pillar for a single-molar restoration.[27] A stronger implant will not solve an overload problem completely but rather divert its consequences to the weak link of the implant system or to the bone contact surface.

CONCLUSION

The preliminary results of this study suggest that osseointegration of immediately loaded single-tooth implants in the posterior region can be achieved. The marginal bone level from the time of implant placement can be preserved. The use of a provisional restoration with an ideal crown form can facilitate the formation of natural contours of the peri-implant mucosa. Although the immediate loading technique allows maintenance of the soft and hard tissue, provides patient comfort and esthetics, and has demonstrated success so far, a longer evaluation period with larger patient populations is needed. Careful patient selection and treatment planning remain significant.

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