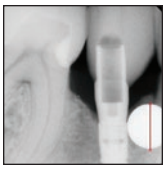
Crestal Bone and Keratinized Tissue Around 3.0-mm Laser-Microtextured Dental Implants After 1 Year in Function: A Case Series



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The purpose of this case series was to evaluate peri-implant tissues in 10 patients at 1 year after placement of a tapered 3.0-mm laser-microtextured dental implant (Laser-Lok, BioHorizons) using a two-stage approach. Clinical and radiographic measurements were assessed. Keratinized tissue at the facial surfaces of each implant had a slight increase of 0.73 mm (95% confidence interval [CI], P = .058), and marginal bone levels had significant increase of 1.85 mm (95% CI, P = .005) at 1 year compared to baseline. These data suggest that 3.0-mm laser-microtextured implants demonstrate stable or improved soft and hard tissue parameters at 1 year postloading. Int J Periodontics Restorative Dent 2019;39:333–339. doi: 10.11607/prd.3667

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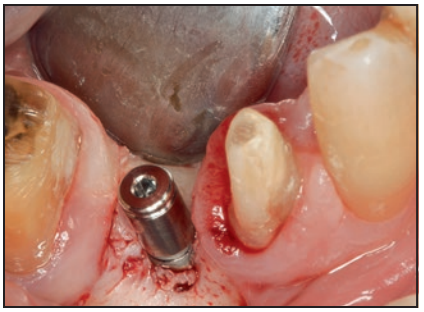
Limited interdental space makes for challenging placement and restoration of implants in the region of single-rooted teeth.[1] Placement of standard-diameter implants (≥ 3.5 mm) are not feasible in the area of maxillary or mandibular teeth when there is limited interdental space or a thin alveolar crest. A 1.5-mm distance is recommended between implants and adjacent teeth to maintain interdental bone and papilla.[2] Additionally, a minimum of 2 mm of hard and soft tissue is required on the buccal aspect of an implant for a successful esthetic and functional outcome.[3] These factors favor the selection of a narrower-diameter implant in limited-space situations. Stability of crestal bone and width of keratinized tissue are crucial from both esthetic and functional perspectives, especially when evaluating implants placed in the anterior region of the maxilla or mandible.[4] While successful use of narrow-diameter implants in the zone of single-rooted teeth have been reported,[5] clinical studies detailing the stability of the crestal bone and soft tissue are lacking.

Therefore, the aim of this case series is to prospectively evaluate the peri-implant soft and hard tissues of patients following placement of a tapered internal 3.0-mm laser-microtextured (Laser-Lok, BioHorizons) implant in the zone



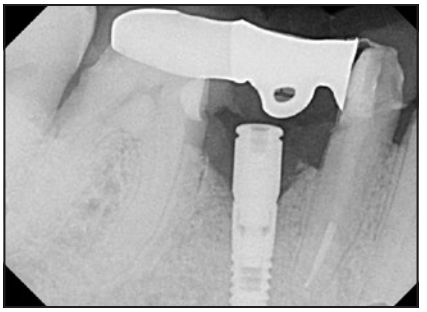


Fig 1 (left) *Surgical view of the implant at time of placement. Full-thickness flap was raised and an osteotomy was prepared based on the manufacturer's protocol.*

Fig 2 (right) *Radiograph at the time of implant placement. The 3.0-mm laser-microtextured (Laser-Lok, BioHorizons) implant placed at the mandibular right second-premolar site with no previous history of grafting at the extraction site.*

of single-rooted teeth immediately after placement, at the time of second-stage surgery, at the time of restoration, and 1 year after superstructure loading.

Materials and Methods

Surgical and Prosthetic Protocol

This prospective study was conducted in a private-practice setting. Ten consecutive patients who required one or more implants to replace teeth in a single-rooted zone were enrolled. This study protocol was approved by a human-subject ethical committee (Western Institutional Review Board), which is accredited by the Association for the Accreditation of Human Research Protection Programs. Consecutive patients who met the inclusion criteria and gave written informed consent were enrolled.

The inclusion criteria included: An edentulous ridge with a mesiodistal width of at least 6 mm and sufficient height to accept a 10.5-mm–long, 3.0-mm–diameter implant; presence of keratinized tissue in the edentulous area; sufficient restorative height and interproximal width for a single-implant crown; and absence of periapical infection or deep caries on adjacent teeth. Patients with nongrafting and grafting surgical histories at the extraction site were included if they had completed a minimum healing time of 3 and 6 months, respectively.

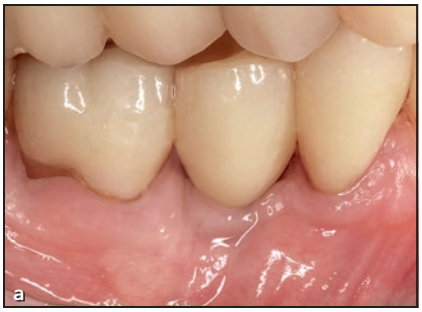
Patients were excluded if they met any of the following criteria: Untreated caries or periodontal disease; need for bone or soft tissue augmentation in the implant site; systemic or local disease or condition that might compromise postoperative healing; absence of occlusal stability in centric occlusion; use of systemic corticosteroids or any other medication that would compromise postoperative healing and/or osseointegration (such as calcium channel blocker or Dilantin); pregnancy or intent to get pregnant within 1 year of initiation of implant surgery; presence of alcohol and/or drug abuse; tobacco smoking of more than half a pack a day; unable or unwilling to return for postoperative follow-up visits for the study period.

A radiographic stent was fabricated for use during the cone beam computed tomography study. The stent was converted to a surgical stent and was used for implant surgery. One hour prior to surgical installation of the fixture, a single dose of either 500 mg amoxicillin or 150 mg clindamycin was administered and continued every 8 hours for the following 7 days. An H-incision was made, and a full-thickness flap was raised. All implant surgeries followed the manufacturer's recommended protocol. In case of uneven ridges, the osteotomy was prepared and the implants placed so that the bone/soft tissue junction was within the Laser-Lok collar. If the ridge discrepancy was more than the Laser-Lok transition zone, leveling the ridge was considered (Figs 1 to 3). To avoid any premature loading of the implants, only fixed provisional restorations were used.

Soft and Hard Tissue Parameters

Clinical Outcomes

Implant outcomes were evaluated using the success criteria proposed by Albrektsson et al,[6] which include the following: absence of persistent subjective complaints (pain, foreign body sensation, and dysesthesia);



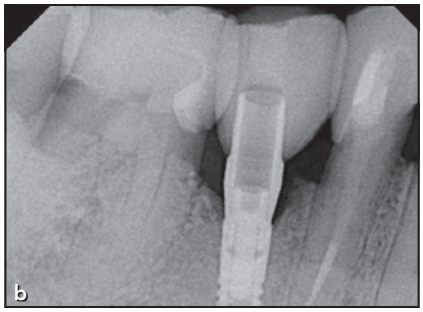


Fig 3 (a) *Clinical photograph at the time of restoration delivery.* (b) *Radiograph at restoration delivery.*

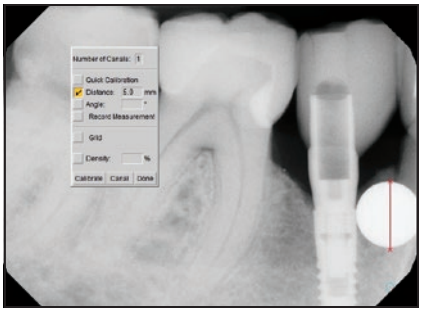
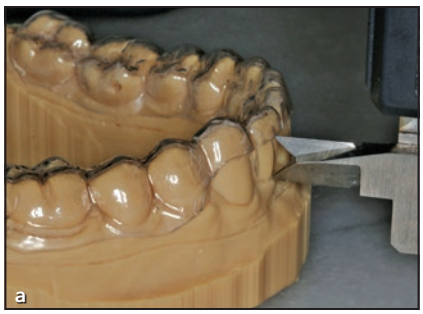


Fig 4 *Radiographic spheres, measuring 5 mm in diameter, were used to assess the accuracy of the measurements of bone level to implant length.*

absence of infection with suppuration; absence of mobility, assessed by bimanual palpation using the handles of two metallic instruments; absence of a continuous peri-implant radiolucency; and marginal bone loss of < 1.5 mm in the first year of function and < 0.2 mm annually in the following years. The hard and soft tissues were assessed at each subsequent visit of the study to determine stability from time of placement to 1 year postloading.



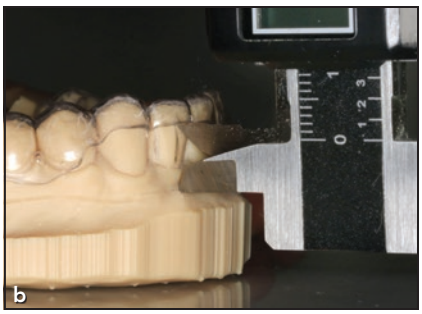


Fig 5 (a) *Measurement from the midgingival line to the template using the digital caliper.* (b) *Measurement from the template to the mucogingival line at midgingiva using the digital caliper.*

Crestal Bone Level

Periapical digital radiographs using Rinn XCP (Dentsply) were taken during and immediately after implant placement, prior to second-stage surgery, at the time of final restoration, and 1 year after final restoration delivery. Each Rinn XCP was standardized using pattern resin to record the bite and allow the authors to replicate the radiograph position at each stage. The radiographs were used to measure the distance from the implant-abutment connection reference point to the adjacent-most coronal bone or bone-to-implant contact on the mesial and distal aspects of the implant. Radiograph measurements were recorded by a single dentist (E.E.C.). The distance was measured under magnification to the nearest 0.1 mm using a calibrated digital caliper and commercially available digital radiograph software (Dexis version 9.4.4, Kavo). Using the radiographic measurement of vertical bone loss by Manz,[7] the software was used to determine the radiographic measurement of the implant length compared to the crestal bone loss. In cases where the implant length could not be captured, the authors used radiographic spheres (Radiographic Markers [item #RM], Osseous Technologies of America) to assess the accuracy of the measurements (Fig 4).

Keratinized Tissue Dimensions

Stone models were fabricated at the time of crown placement and at 6 months and 1 year later. A template was created from the first model and was used to measure the distance from the midgingiva to the template and the mesial and distal transitional angles using an electronic digital caliper (model 01407A, Neiko) at the stated time intervals. For all collected data (midgingival distance, mesial transitional angle, and distal transitional angle), two measurements were made: one from the template to the gingival margin and another from the template to the mucogingival line (Fig 5). The two measurements were de-

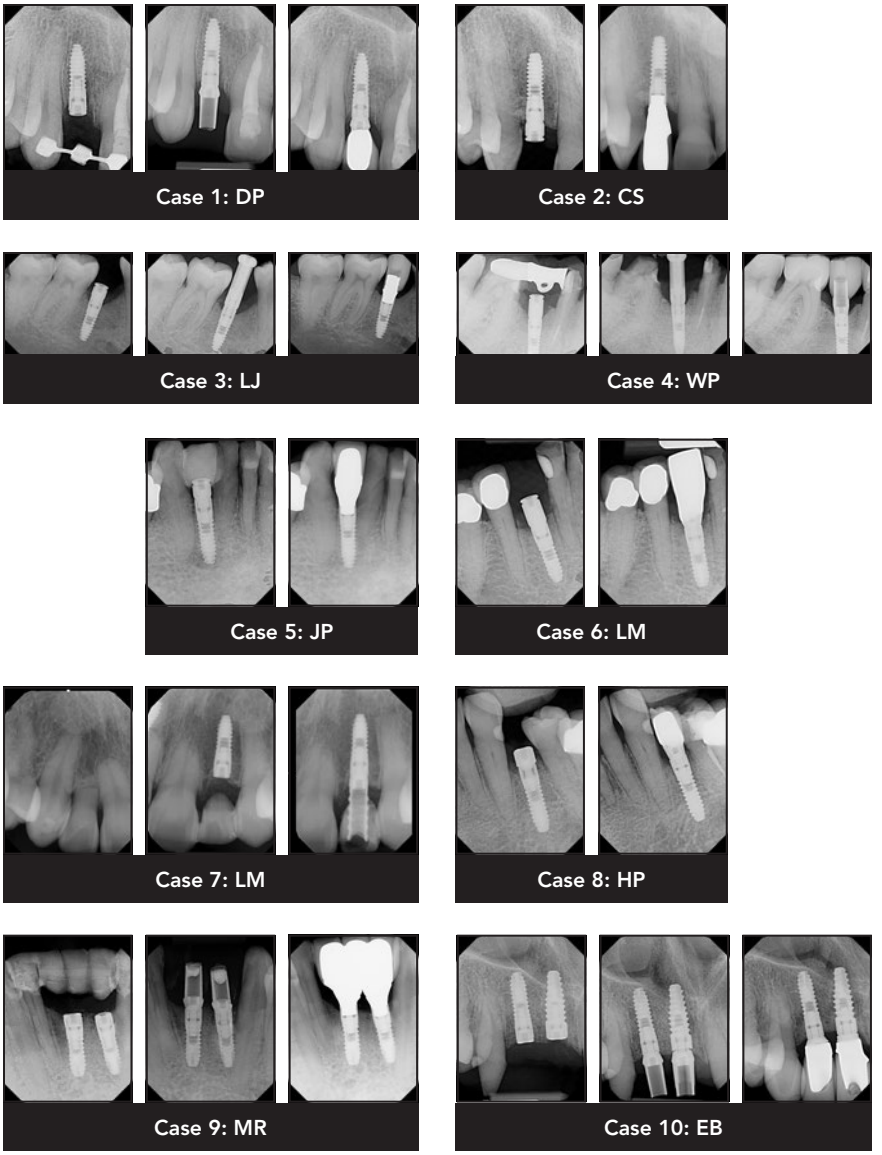


Fig 6 *Radiographs at time of placement (baseline) and 1 year after loading for all 10 cases.*

ducted from one another to come up with the keratinized tissue height at the stated time intervals.

Statistical Analysis

For radiographic measurements, mesial and distal values were averaged for each implant at each time point. For the keratinized soft tissue variable, proximal and midfacial values were averaged for each implant at each of two time points. Paired *t* test was used to compare soft tissue and radiographic variables. The measurements made at the time of implant placement were compared with subsequent study-visit time points. The level of significance was set at $P \leq .05$ for all statistical tests. Bonferroni method was used to adjust for multiple comparisons. The data were analyzed using a statistical program (STATA, version 9).

Results

A total of 10 patients (6 men, 4 women; mean age: 63.2 years; range: 29 to 87 years) were consecutively enrolled in the study. Of the 10 implants, 1 was placed in the mandibular incisor area, 4 in the maxillary lateral incisor areas, 1 in the mandibular canine area, and 4 in the mandibular premolar areas. All patients experienced an uneventful postoperative course. All implants met the success criteria of Albrektsson et al[6] at the 1-year follow-up. Radiographs of all cases are shown in Fig 6.

Average bone levels at baseline were –0.63 mm (95% confidence interval [CI]: –1.2 to –0.09), meaning that the implant shoulder was on average slightly supracrestal but within the microtextured collar, according to the manufacturer's recommended protocol. Compared with baseline, bone levels were 0.5 mm (95% CI: –0.56 to 1.56 mm; $P = .048$) at second-stage surgery; 0.65 mm (95% CI: –0.34 to 1.63 mm; $P = .021$) at the time of restoration; and 1.22 mm (95% CI: 0.22 to 2.22 mm; $P = .005$) 1 year after loading. This represents a mean gain in crestal bone height of 1.85 mm (95% CI: 0.7 to 3.0 mm) during the study period (Fig 7). Keratinized tissue levels were measured at baseline and 1 year postloading. On average, keratinized tissue levels increased

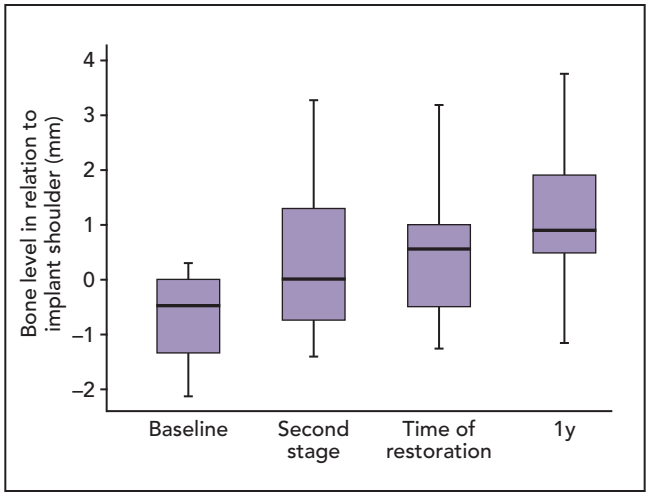


Fig 7 *Box plot of bone levels measured immediately after placement (baseline), at second-stage surgery, at the time of restoration, and at 1 year after superstructure loading. A gain in crestal bone height of 1.85 mm (95% CI: 0.7 to 3.0 mm) was seen during the study period: from –0.63 mm (95% CI: –1.2 to –0.09 mm) at baseline; 0.5 mm (95% CI: –0.56 to 1.56 mm; P = .048) at second-stage surgery; 0.65 mm (95% CI: –0.34 to 1.63 mm; P = .021) at the time of restoration; and 1.22 mm (95% CI: 0.22 to 2.22 mm; P = .005) 1 year after loading.*

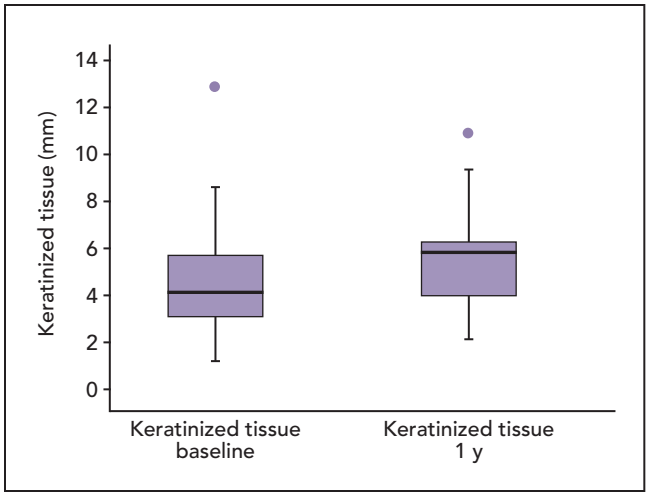


Fig 8 *Box plot of keratinized tissue levels measured at the midfacial and interproximal aspects of the implant at the time of placement and at the 1-year follow-up after implant restoration. On average, keratinized tissue levels increased 0.73 mm (95% CI: –0.3 to 1.50 mm; P = .058) from 5.02 mm (95% CI: 2.5 to 7.5 mm) at baseline to 5.75 mm (95% CI: 3.8 to 7.7 mm) at the 1-year follow-up after implant restoration.*

0.73 mm (95% CI: –0.3 to 1.50 mm; *P* = .058), from 5.02 mm (95% CI: 2.5 to 7.5 mm) at baseline to 5.75 mm (95% CI: 3.8 to 7.7 mm) at the 1-year follow-up, but failed to reach statistical significance (Fig 8).

Discussion

The primary aim of this study was to evaluate the stability of crestal bone levels and keratinized tissue around tapered internal 3.0-mm laser-microtextured implants placed in limited interdental space situations in areas of single-rooted teeth. The main finding of the present study was that both keratinized tissue and crestal bone levels increased at the 1-year follow-up compared to baseline levels. Further, increases in crestal bone were observed at each time point in the study and were statistically significant at the 1-year follow-up. By the final study visit, no study implant experienced bone loss; all had bone gain. While implant stability has been documented in the literature, to the authors' knowledge, this study is the first to document statistically significant short-term crestal implant bone gain following loading of a prosthesis. Future studies with larger sample sizes and comparison groups are needed to confirm and expand these findings. Nonetheless, this study has demonstrated that the tapered internal 3.0-mm laser-microtextured implant appears to represent a successful and predictable solution in esthetically demanding tooth-replacement situations when placed in the esthetic zone.

These small-diameter implants were placed in demanding esthetic and functional sites with limited bone width and interdental space. This 1-year study demonstrated that all 10 implants achieved and maintained successful tissue integration. All implants met the study's success criteria with a survival rate of 100%. The crestal bone level and band of keratinized tissue remained stable or increased over the course of the study. No major prosthetic or physical complications were observed with the tapered internal 3.0-mm laser-microtextured implants.

The main finding, of statistically significant increase in bone levels around implants from baseline to the time of restoration, in this study is in contrast to previous investigations. Sohn et al found in

a 33-month retrospective analysis with one-piece implants that the mean marginal bone loss was 0.53 mm.[8] Reddy et al reported a high success rate of 96.7% in 17 patients treated with 31 one-piece implants, with crestal bone loss averaging 0.58 mm in the initial 6 months with no significant changes observed later.[9] Both of the above studies used resorbable blast-surface texture and square-threaded 3.0-mm implants (Maximus, BioHorizons) in contrast to the present study, which used Laser-Lok.

In a 36-month follow-up study, Degidi et al[10] showed accumulated mean marginal bone loss between 0.75 to 0.85 mm around their 3.0-mm–diameter parallel screw, grit-blasted and acid-etched implant with an internal hexagonal connection (XiVE Plus, Dentsply Sirona). Zembić et al[11] reported comparable results with an average bone loss of 1.6 mm at 12 months. The 3.0-mm implant (NobelDirect, Nobel Biocare) used in that study was a one-piece implant with a machined-surfaced abutment, while the implant neck (located at the marginal bone and supracrestal soft tissues) was a straight oxidized surface, and the endosseous portion was threaded and oxidized. In a 3-year prospective study, Pieri et al reported 0.22 mm of crestal bone loss around 3.0 mm fluoride-modified–surfaced implants with microthreads at the implant neck (OsseoSpeed, Astra Tech).[12]

While the present study included only 10 implants, survival rates were 100% at 1 year postloading. This finding is also in contrast with other reports from the literature on small diameter implants in the esthetic zone. Vigolo and Givani reported in a 5-year retrospective study of 2.9-mm–diameter mini-implants (Zimmer Biomet) made of resorbable blasting media with 1.5-micron surface roughness for standard single-tooth implant restorations, a total implant survival rate of 94.2%.[13] A systematic review for dental implants with a diameter between 3.0 and 3.25 mm (mostly two-piece implants inserted into narrow tooth gaps without loading and in the frontal region) showed a survival rate ranging between 93.8% and 100%.[14]

The present study demonstrated a statistically significant increase in bone levels of 0.59 mm and a nonsignificant increase of keratinized tissue of 0.73 mm over the 1-year study period. The authors hypothesize that these positive findings can be attributed to the laser-microgroove feature of the collar of the Laser-Lok implant. The microgrooves of this implant type are smaller in dimension by an order of magnitude compared with other grooved surfaces. Histologic studies in humans have shown the presence of a physical connective tissue attachment onto laser-produced microgrooves on implant and abutment surfaces.[15–17] These connective tissue fibers were oriented perpendicularly to the implant surface and may serve to prevent apical migration of gingival epithelial cells and fibroblasts. Based on the histologic findings together with the present clinical findings, the authors propose that the laser-microtextured surface of the implant plays a key role in preserving the integrity of the coronal levels of bone and soft tissue. This falls in line with what Nevins et al have shown histologically; collagen fibers functionally oriented towards the grooves on the Laser-Lok implant surface contributing to new bone remodeling in the coronal direction.[17] Limitations of this study include small sample size and lack of a comparison group. Future studies with larger sample sizes and longer follow-up period are warranted given the positive clinical outcomes in the present study.

Conclusions

This prospective study demonstrated that tapered internal 3.0-mm laser-microtextured implants showed excellent bone and soft tissue stability 1 year after placement and were a predictable treatment option for tooth replacement in the anterior area with narrow interdental spaces for up to 1 year of loading. These positive findings are potentially of considerable clinical significance if confirmed in larger studies with longer-term follow-ups.

Acknowledgments

All authors *(1)* made substantial contributions to the conception or design of the work; or the acquisition, analysis, or interpretation of data for the work; *(2)* drafted or revised the paper critically; *(3)* approved the final version to be published; and *(4)* agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any parts of the work are appropriately investigated and resolved. The authors have no conflicts of interest.

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