The Impact of a Laser-Microtextured Collar on Crestal Bone Level and Clinical Parameters Under Various Placement and Loading Protocols

Renzo Guarnieri, MD, DDS[1]/Mario Serra, MD, DDS[2]/Luca Bava, MD, DDS[2]/ Maurizio Grande, DDS[3]/Davide Farronato, DDS, PhD[4]/Vincenzo Iorio-Siciliano, DDS, PhD[5]

Purpose: *Physical attachment of connective tissue fibers to a laser-microtextured (8- and 12-μm grooves) surface on the collar of an implant has been demonstrated using human histology. Related clinical research has suggested that this microtextured surface may help to decrease initial bone loss after implant placement. The aim of this retrospective study was to compare crestal bone heights and clinical parameters between implants with laser-microtextured and machined collars placed and loaded with different protocols.* ***Materials and Methods:*** *This study evaluated 300 single implants in 300 patients (155 men, 145 women; mean age: 49.3 years; range: 45 to 75 years). One hundred sixty implants with laser-microtextured collars (L) and 140 with machined collars (M) were used. Implants were grouped into the treatment categories of immediate placement, delayed placement, immediate nonocclusal loading, and delayed loading. For all groups, crestal bone level, attachment level (CAL), Plaque Index, and bleeding on probing were recorded at baseline and 6, 12, and 24 months after loading with the definitive restoration.* ***Results:*** *Nine implants were lost (four L and five M). The type of implant and timing of placement and loading showed no significant influence on survival rates. A mean CAL loss of 1.12 mm was observed during the first 2 years in the M group, while the mean CAL loss observed in the L group was 0.55 mm. Radiographically, L group implants showed a mean crestal bone loss of 0.58 mm, compared to 1.09 mm for the M group.* ***Conclusion:*** *A laser-microtextured surface on the implant collar may mitigate the negative sequelae associated with peri-implant bone loss, regardless of the placement and loading protocols used.* Int J Oral Maxillofac Implants 2014;29:xxx–xxx. doi: 10.11607/jomi.3250

Key words: *delayed loading, delayed placement, immediate nonocclusal loading, immediate placement, laser microtexturing*

The use of osseointegrated implants to support prosthetic reconstructions has become a common treatment modality for partially and completely edentulous patients. The original Brånemark protocol, which recommended complete healing of the alveolar bone before placing an implant, along with a healing period of 3 to 6 months before loading the implant, has been greatly modified in the last two decades, and shorter treatment periods to allow for immediate or early loading of implants, as well as immediate implant placement, have been advocated.[1–10] Immediate placement is defined as the placement of an implant into a fresh extraction socket.[11] The successful implementation of this protocol has been demonstrated for some cases, with predictable treatment outcomes.[12–18] Modifications of this approach, such as placement after a short healing period of several days to several weeks, have been associated with variable survival rates.[13,19,20]

The existing literature provides definitions of immediate loading, early loading, and immediate nonocclusal loading (INOL) that sometimes differ. Immediate loading usually refers to the placement of a restoration in functional contact at the time of implant placement.[21] Early loading is usually defined as the placement of a restoration after a healing period shorter than that of the original Brånemark protocol.[22] INOL refers to the placement of a restoration that is not in functional contact at the time of implant placement.[21]

[1]Private Practice Limited to Implants, Rome, Italy; Freelance Researcher, SCS Scientific Consulting Services, Rome, Italy.
[2]Private Practice Limited to Implants, Chieri, Turin, Italy.
[3]Private Practice Limited to Implants, Rome, Italy.
[4]Assistant Professor, Department of Biomaterial Sciences, Insubria University, Varese, Italy.
[5]Assistant Professor, Department of Periodontology, University of Naples Federico II, Naples, Italy.

Correspondence to: Renzo Guarnieri, SCS Scientific Consulting Services, Via Paolo Emilio 7/5 00144 Rome, Italy. Email: renzoguarnieri@gmail.com

These approaches have shown predictable results when patients are selected appropriately.[23] In addition to changes in placement protocols and advancements in techniques for site preparation, new implant designs[24–26] and several modifications of surface characteristics[27–33] have been investigated in an effort to improve marginal soft and hard tissue integration and to decrease the amount of initial peri-implant bone loss. Regarding implant surfaces, recent tissue culture studies have demonstrated cellular attachment by osteoblasts and fibroblasts to laser-microtextured surfaces with 8- and 12-μm grooves.[34,35] These data have been confirmed histologically in animal models[36] and in humans,[37] in which a physical connective tissue attachment to laser-produced microgrooves on implant and abutment surfaces was documented. This kind of attachment differs significantly from that traditionally associated with implants.[38,39] The most important aspects of this physical connective tissue attachment are the fact that its position is determined by the layout of the laser microgrooves[36] and that the connective tissue fibers are perpendicularly oriented to the implant surface and act as a seal to prevent apical migration of gingival epithelial cells and fibroblasts. Thus, it has been hypothesized that an implant with a microtextured collar surface with 8- and 12-μm grooves might provide opportunities for more stable coronal fibrocollagenous physical attachment and might potentially mitigate or eliminate the negative sequelae associated with the crestal bone loss that is commonly observed and has been described in the literature.[29,40–45] The first clinical data presented[27,46] seem to confirm this hypothesis: implants with a laser-microtextured collar showed reduced crestal bone loss and probing depths in comparison to machined-collar implants. However, at this time insufficient data are available to compare treatment outcomes of this kind of implant using different protocols. In the present study, therefore, the 2-year success rates of two different kinds of implants (laser-microtextured collar [L] versus a machined collar [M]) were investigated, with the aim to determine whether the laser-microtextured collar influenced clinical outcomes when different protocols were used: immediate placement, delayed placement, INOL, and delayed loading (DL).

MATERIALS AND METHODS

This study was not randomized and was based in a private practice. All patients considered for inclusion in the study were examined and treated between January 2008 and December 2011 in private dental clinics located in Italy; all of the treating dentists had extensive experience in clinical implant dentistry. No ethical or institutional review board approval was sought; however, all patients signed an informed consent document. Patients were selected for this study according to the following criteria: (*1)* participants had no contraindications for treatment, such as systemic diseases (eg, diabetes), pregnancy, regular use of prescription medications, or consumption of recreational drugs; *(2)* the teeth adjacent to the implant area (mesially and distally) had to be present and free of overhanging or insufficient restoration margins and/or caries (restorations and caries lesions were repaired during the initial professional oral hygienic therapy); *(3)* patients who smoked more than 10 cigarettes a day were excluded; and *(4)* teeth with periapical active pathology (presence of pain, fistula, redness, and suppuration) were excluded from the study. Only one implant scheduled for restoration with a single crown per patient was selected. Subjects were categorized as smokers if they smoked 1 to 10 cigarettes per day (n = 138 of 291 subjects [47.4%]). Teeth scheduled for extraction and immediate implant placement were supragingivally and subgingivally scaled, root planed, and extracted subsequently during implant surgery. Patients received detailed information on the two kind of implants used (described subsequently) and a full description of the surgical procedures and possible risks of immediate placement and/or immediate loading. All patients provided informed consent to participate in this study, and all treatment was performed in accordance with the Helsinki Declaration.

Two different implants (Tapered Internal TLX Laser-Lok and TRX, BioHorizons) were used. Both implants have the same design and the same surfaces (Resorbable Blast Texturing surface with roughness between 0.72 and 1.34 μm), with the exception that the Laser-Lok implant has a “dual bioaffinity” collar with an implant neck consisting of two types of microgrooves. The Laser-Lok implant neck comprises three sections: a 0.3-mm section of turned surface, a 0.7-mm section of 8-μm microgrooves with a 6-μm pitch, and a 0.8-mm section of 12 microgrooves with a 12-μm pitch (Fig 1). The TRX implant neck comprises two sections: a 0.3-mm section of turned surface and a 1.5-mm section of the Resorbable Blast Texturing surface (Fig 2).

Diagnostic casts were made and mounted on a semiadjustable articulator using a facebow and a bite registration. Occlusal analysis was performed, diagnostic wax-ups were prepared on the articulated casts, and restorative treatment needs were determined. Demographic data, medical and dental health history, and smoking status were obtained by questionnaire. Periodontal status was determined by a comprehensive periodontal examination. All patients demonstrated good oral hygiene and compliance (mean probing depth: 2.2 ± 0.7 mm; bleeding on probing [BOP]: 6%; Plaque Index [PI]: 8%).

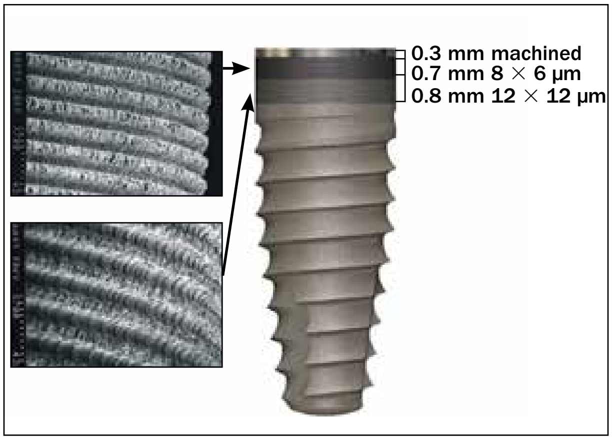

Fig 1 Collar surface characteristics of Laser-Lok (TLX) (microtextured) implant (left: magnification ×700).

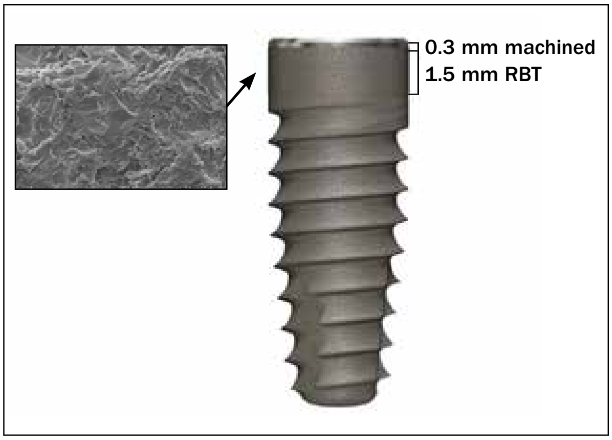

Fig 2 Collar surface characteristics of TRX (machined) implant (left: magnification ×700).

Surgery

Following elevation of a full-thickness flap, site preparation was performed, and implant positioning was performed with a torque driver (Precise Adjustable Torque Wrench, BioHorizons). The inclusion criterion was a final torque of at least 35 Ncm. After extraction and immediate implant placement, any fenestrations of the buccal and/or lingual plate and any gap between the implant shoulder and the socket wall were augmented using mineralized allograft bone chips (MinerOss, BioHorizons) and covered with a bioabsorbable membrane (Mem-Lok, BioHorizons).

Delayed implant placement was performed in some patients 6 months after socket augmentation. The decision to delay implant placement was based on the following intraoperative findings: (*1*) the extraction site required extensive augmentation, and the implant was too narrow to properly fill it; *(2)* active periapical pathology was present; *(3)* implant positions were potentially unfavorable and difficult to restore; or *(4)* the implant showed no primary stability. In these cases, the extraction socket was cleaned, grafted with mineralized allograft bone chips (Miner-Oss, BioHorizons), and covered with a resorbable membrane (Mem-Lok, BioHorizons). The flap was repositioned and sutured in place with interrupted sutures.

Implant Loading

A provisional abutment was used for INOL. After closure of the surgical area with a mucoperiosteal flap, impressions were taken, and the jaw relationship was recorded. Provisional crowns were fabricated the same day and left out of functional occlusion. Both immediate- and delayed-placement implants were ultimately restored with porcelain-fused-to-metal cemented single crowns, placed in centric occlusion, 4 months after implant placement.

Medication and Postoperative Care

Patients scheduled for surgery were prescribed an analgesic (ibuprofen, 600 mg immediately after the surgical intervention and after 4 hours), a systemic antibiotic (amoxicillin + clavulanic acid 1 g two times daily for 7 days), and chlorhexidine digluconate solution 0.1% rinse (twice daily until 1 week after membrane removal). Sutures were left in place for 1 week. During the healing period, patients received oral hygiene instructions and debridement, if necessary, at twice-monthly appointments with the dental hygienist. At the time of placement of the definitive crowns, patients were enrolled in a maintenance program consisting of semiannual follow-up appointments. At the follow-up visits, oral hygiene instructions were given, and debridement and polishing were performed. BOP, PI, and clinical attachment level (CAL) were recorded on four surfaces of each implant supporting the definitive crowns. CAL, defined as the distance in millimeters between the deepest point of the peri-implant pocket and the coronal margin of the implant, was estimated with a periodontal probe (PCP-UNC 15, Hu-Friedy). Measurements were recorded at the time of definitive crown placement (baseline) and at 6 (T1), 12 (T2), and 24 months (T3) after loading.

Radiographic Examination

A personalized radiographic stent was used for every patient for all radiographs (baseline and 6, 12, and 24 months). The radiographs were then digitized with a dedicated scanner (HP 3000) with a resolution of 2,048 × 3,072 lines. A software package (AutoCAD 2000) was used to measure crestal bone loss (CBL). The program calculated the lengths of the vertical lines, which represented CBL as the distance from the top of the implants to the crestal bone.

Success Ratings

The following conditions were considered to indicate implant success: optimum health conditions; absence of implant mobility in any direction; absence of peri-implant radiopacity/radiolucency at radiographic assessment; bone loss of less than 1.5 mm at 24 months; absence of suppuration, infection, and paresthesia; and absence of pain with palpation, percussion, or function. Failure was defined as the removal of an implant for any reason.

Data Analysis

The Kolmogorov-Smirnov test was used to detect significant deviations in outcomes from a normal distribution. Nonparametric methods were used to determine to what degree age, gender, smoking, jaw, region, implant type, and time of placement and loading influenced CAL and CBL measurements from baseline to T3. Changes in CAL and in CBL were evaluated similarly. The Spearman rank correlation or Mann-Whitney *U* test was used. Repeated-measures analysis of variance (ANOVA) was used to determine variations in CAL and CBL over time. The %BOP and %PI, as well as changes within each of these variables, were statistically evaluated in the same way as the CAL and the CBL measurements. Univariate analysis was first performed using the nonparametric Spearman rank correlation or Mann-Whitney *U* test. This was followed by repeated-measures ANOVA to investigate changes over time. All statistical tests were two-sided, and the level of significance was set at 1%. Because of the multiple testing, an α adjustment according to Bonferroni was applied. The statistical analyses were performed using statistical software (SPSS for Windows).

Calibration of Examiners

The examiners were calibrated by measuring the same 40 implants (20 L and 20 M) 1 week apart, and an intraexaminer reliability of 90% was achieved (data not shown). The examiners were recalibrated once a year by measuring 20 implants (10 L and 10 M) following the initial protocol.

RESULTS

The study group included 300 implants that were placed in 300 patients (160 men and 140 women; mean age 49.3 years; range, 43 to 75 years). Nine implants were lost during the study period; thus, the final study group included 291 implants in 291 patients (157 men and 134 women; mean age: 49.3 years; range: 45 to 75 years). One hundred thirty-eight of the 291 subjects (47.4%) were smokers. Implants were grouped according to time of placement into immediate placement (IP; total 166 implants; 86 L and 80 M) and delayed placement (DP; total 134 implants; 72 L and 62 M). The time of loading was also used to group the implants into INOL (total: 173 implants; 102 L and 71 M) and DL (total: 127 implants; 67 L and 60 M) groups. Among the implants placed in this study, 138 were placed in the maxilla (82 L and 56 M) and 162 were placed in the mandible (91 L and 71 M).

The distribution of treatments among the study groups and implant success and failure rates are summarized in Tables 1 and 2. The two implant groups showed no significant difference in implant failure rates (L 2.5%, M 3.8%; χ^2 test: $P > .05$). The mean time in situ of failed implants was 81.6 days, with a standard deviation of 54.3 days and a relatively high variance (range: 5 to 224 days). The variables of gender, smoking, jaw, and time of placement and loading showed no significant influence on implant removal (χ^2 test: $P > .05$).

Univariate statistical analysis showed no significant effects of age (Spearman correlation: $R < 0.2$, $P > .05$), gender, position, or time of placement and/or loading (U test; $P > .05$) on general CAL outcomes or CAL change between the different time examinations. Instead, a general comparison of CAL outcomes for baseline to T3 showed a significant change (repeated-measures ANOVA; $P < .001$), with CAL in the L group significantly higher than in the M group over the entire observation period (Table 3). Compared to baseline, at T1, a CAL loss of 0.43 mm was observed for L and CAL loss of 0.85 mm was seen for M; at T2 and T3, further CAL losses of 0.09 mm and 0.07 mm, respectively, were observed for L, compared to 0.53 mm and 0.09 mm, respectively, in the M group (Fig 3). The CAL changes were not associated with the timing of implant placement or loading. Univariate analysis of %BOP and %PI at each examination, as well as changes between examinations, demonstrated no significant influence of age, gender, implant type, jaw, region, and time of placement or loading (*U* test; $P > .05$). Furthermore, a comparison of %BOP and %PI showed no change between baseline and T3 (repeated-measures ANOVA, linear contrasts; $P > .05$).

Radiographic results of CBL are summarized in Table 4. At T1, T2, and T3, the L group had mean CBL values of 0.34 mm, 0.53 mm, and 0.58 mm, respectively, compared to 0.74 mm, 0.97 mm, and 1.09 mm, respectively, for the M group. Results showed a statistically significant correlation between the two groups (Fig 4), but

Table 1 Implant Success and Failure Rates Among 300 Patients

Parameters	No. placed	% successful	% failed	No. failed	Mean time in situ of failed implants (d) ± SD (range)
Implant type					
L	160	97.5	2.5	4	83.8 ± 92.3 (28 to 181)
M	140	96.5	3.5	5	79.4 ± 64.7 (5 to 224)
Gender					
M	159	96.1	3.8	6	59.1 ± 17.3 (5 to 124)
F	141	97.9	2.8	3	118.3 ± 98.7 (21 to 224)
Smoker					
No	162	98.8	1.2	2	115.8 ± 110.2 (20 to 224)
Yes	138	94.4	3.6	7	46.9 ± 52.3 (5 to 194)
Region					
Anterior maxilla	78	97.7	2.7	2	85.4 ± 71.9 (5 to 160)
Posterior maxilla	60	94.5	5.5	3	69.3 ± 135 (21 to 190)
Anterior mandible	76	97.3	2.7	2	82.4 ± 97.3 (31 to 224)
Posterior mandible	86	96.4	3.6	2	70.7 ± 91.7 (25 to 224)
Time of placement					
IP	166	94.9	5.1	8	19 ± 9.9 (5 to 45)
DP	134	99.3	0.7	1	80 ± 91.4 (25 to 224)
Loading					
INOL	173	97.2	2.8	5	44.8 ± 29.3 (5 to 86)
DL	127	96.9	3.1	4	87.3 ± 105 (25 to 86)
Placement + loading					
IP+ INOL	100	95.9	4.1	4	97.3 ± 25.8 (5 to 70)
IP + DL	66	95.3	4.7	3	68.9 ± 77.0 (5 to 120)
DP + INOL	78	99.8	0.2	1	45.8 ± 35.4 (25 to 86)
DP + DL	56	99.9	0.1	1	109.8 ± 12.7 (41 to 106)
Total	300	97.0	3.0	9	72.9 ± 77.3 (5 to 224)

The variables of gender, smoking, region, and time of placement and loading showed no significant influence on implant failure (χ^2 test, $P > .05$).

the CAL and CBL changes were not associated with the timing of implant placement or loading.

DISCUSSION

This study demonstrated no significant differences in the 2-year success rates of two kinds of implants with different collar surfaces, regardless of the timing of placement and the loading protocol. Similar success rates were seen for both groups (L 97.5%; M 96.5%) and were not influenced by region, time of placement and/or loading, or age. No significant differences were found between female and male patients, nonsmokers and smokers, and DP and IP. These data are in agreement with previous studies[47–50] that demonstrated similar survival rates for implants irrespective of the implant design. Furthermore, within the two different implant types (L and M), age, gender, position, and time of placement and/or loading did not affect CAL and CBL values in this study. Instead, a difference in the pattern of CAL and of CBL changes was found when comparing the L and M groups over the entire observation period. A better CAL value and less CBL were found in the present study in the L group.

The literature has a limited number of publications regarding long-term outcome data of immediate implants replacing single missing teeth with immediate loading.[5,51–57] In general, studies indicate that, once IL implants integrate, they appear to have success rates, bone loss, and soft tissue stability comparable to those of conventionally loaded implants. Success rate outcomes in the INOL group of the present study are similar to those reported in the literature, and these results seem to confirm that the slight forces exerted on implants with restorations left out of occlusion did not have a negative influence on bone formation; however, in patients treated with the INOL protocol, there was a statistically significant difference in CBL and

Table 2 Distribution of Treatments Among the Study Groups

Implant treatment/ implant type	No. placed	Mean age (y) ± SD (range)	Gender (n [%]) F/M	Smoker (n[%]) N/Y
IP				
L	86	50 ± 11.0 (29 to 73)	40 (46.5)/46 (60.4)	44 (40.8)/65 (59.2)
M	73	48.2 ± 9.2 (26 to 67)	44 (60.2)/29 (39.8)	49 (54.8)/44 (45.2)
Total	159	49.1 ± 10.1 (26 to 73)	84 (52.8)/75 (47.8)	93 (47.9)/109 (52.1)
DP				
L	72	49.5 ± 10 (25 to 72)	38 (53.8)/34 (46.2)	39 (54.1)/33 (45.9)
M	60	47.2 ± 8.8 (28 to 68)	29 (48.9)/31 (51.1)	42 (70.0)/18 (30.0)
Total	132	48.4 ± 9.5 (25 to 72)	67 (50.7)/65 (49.3)	81 (61.3)/51 (38.7)
INOL				
L	102	48.6 ± 9.5 (29 to 67)	47 (46.3)/55 (53.7)	57 (55.8)/45 (44.2)
M	83	50.7 ± 12.1 (25 to 75)	35 (42.1)/48 (57.9)	45 (54.2)/38 (45.8)
Total	185	49.7 ± 11.0 (25 to 75)	82 (44.2)/103 (55.8)	102 (55.0)/83 (45.0)
DL				
L	53	48.7 ± 8.3 (34 to 64)	26 (48.8)/27 (51.2)	16 (30.1)/37 (69.9)
M	53	48.2 ± 7.4 (38 to 64)	26 (48.8)/27 (51.2)	38 (71.7)/15 (28.3)
Total	106	48.5 ± 7.2 (34 to 64)	26 (48.8)/27 (51.2)	54 (50.9)/52 (49.1)
IP and INOL				
L	46	51.8 ± 10.8 (29 to 74)	21 (45.7)/25 (54.3)	24 (52.1)/22 (47.9)
M	40	25.1 ± 8.4 (28 to 67)	19 (38.0)/31 (62.0)	23 (54.0)/27 (46.0)
Total	96	37.6 ± 10.4 (28 to 74)	40 (41.7)/56 (58.3)	47 (53.5)/49 (46.5)
IP and DL				
L	33	51.4 ± 9.2 (33 to 66)	12 (36.0)/21 (64.0)	7 (21.1)/21 (78.8)
M	30	50.4 ± 9.4 (33 to 63)	19 (63.3)/11 (36.7)	17 (56.6)/13 (43.4)
Total	63	50.9 ± 8.3 (33 to 66)	31 (49.6)/32 (50.4)	24 (38.9)/34 (61.6)
DP and INOL				
L	43	47.9 ± 10.2 (28 to 60)	20 (46.5)/23 (53.5)	26 (60.4)/17 (39.6)
M	34	46.3 ± 9.1 (29 to 64)	18 (53.0)/16 (47.0)	19 (56.0)/15 (44.0)
Total	77	47.2 ± 10.9 (28 to 64)	38 (49.7)/39 (50.3)	45 (58.2)/32 (41.8)
DP and DL				
L	37	23.2 ± 8.2 (39 to 57)	18 (66.7)/9 (33.3)	12 (44.4)/15 (55.6)
M	28	46.2 ± 10.4 (36 to 60)	13 (46.4)/15 (53.6)	19 (67.9)/8 (32.1)
Total	55	34.7 ± 7.9 (36 to 60)	31 (56.5)/24 (43.5)	31 (56.1)/23 (43.9)

CAL between the L group and the M group. A recent review of the literature[58] indicated, for immediately placed implants, success rates comparable to those of delayed implants, but no study reported a frequency distribution on ranges of marginal bone loss for immediately placed implants. In the present study, CAL and CBL changes were not associated with the timing of implant placement or loading; however, the results showed a statistically significant correlation of CAL and CBL between the two groups (L and M).

The results of this study are in agreement with the initial clinical evaluations of implants with a laser-microtextured collar[27,28,46] but support the hypothesis that this kind of collar, compared to a machined collar and using different protocols, may provide more favorable conditions for the attachment of hard and soft tissues and may reduce the amount of marginal bone resorption. The precise mechanisms of bone resorption around dental implants are not yet completely known, but perioprosthetic aspects have been investigated with regard to soft tissue and bone remodeling. Bone loss may result from implant design, density of bone, surgical trauma at implant insertion or at second-stage surgery, occlusal overloading, apical migration of crevicular epithelium in the tissue's attempt to isolate bacterial-induced infection or to establish a biologic width, blood supply interruption, or development of a pathogenic bacterial biofilm.[40–44] As is the case with teeth, epithelium seems to play an important role in implant function by sealing dental implants from contaminants in the external environment. Around implants, epithelial downgrowth could be impeded by a firm attachment between the soft connective tissue and the implant, with cells and fibers attached to the implant surface, as is the case with Sharpey's fibers around natural teeth. In healthy tissue, collagen bundles insert into the root cementum, and this connection prevents downgrowth of the overlying epithelium. Connective tissue does not usually attach to the titanium substrate in this manner. In the case of

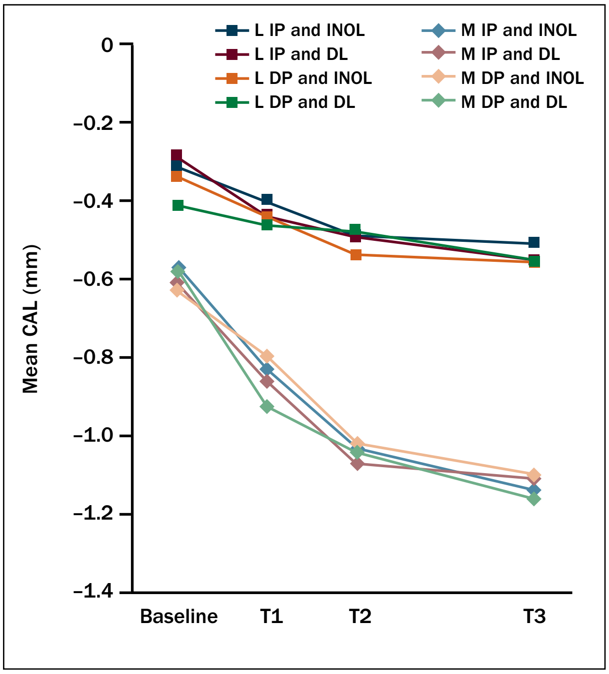

Fig 3 CAL outcomes over the study period. The difference between the observed means in L and M groups was significant ($P < .01$).

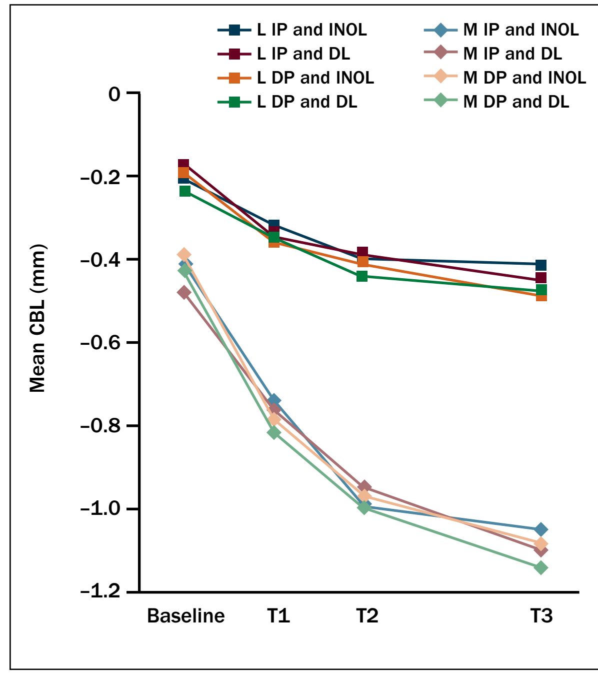

Fig 4 CBL outcomes over the study period. The difference between the observed means in L and M groups was significant ($P < .01$).

a smooth implant surface, the attachment and spreading of fibroblasts can result in the establishment of a fibrous capsule with collagen fibers oriented parallel to the implant surface.[29]

The clinical value of a microtextured implant collar on soft and hard peri-implant tissue response is currently unclear. However, the effect of a microgrooved surface with features in the range of 2 to 12 µm with respect to attachment, spreading, orientation, and growth of fibroblast and osteoblast precursors has been examined in several in vitro studies.[59,60] Surfaces with 12-µm grooves showed the best potential for inhibition of fibroblast cell–type growth relative to osteoblast cell–type growth, while surfaces with 8-µm grooves showed the most effective inhibition of cell migration across the grooves. These in vitro studies seem to provide evidence that microtextured surfaces can be used to control bone and soft tissue responses to implant surfaces, and their clinical implications may be important. In fact, it has been suggested that on dental implants, the microgrooved surfaces might act to establish a predetermined site to attract a physical connective tissue attachment, to restrict apical migration of gingival epithelium, and thus to preserve the coronal level of bone.[37]

Today there is histologic evidence of a mechanical attachment of connective tissue fibers to laser-microtextured implant surfaces, both in native bone[36,37] and in fresh extraction sites,[61] but histologic data relating to the relationship between soft and hard tissue and implants with a laser-microtextured surface, placed using different loading protocols, are still not widely available. While the present study did not demonstrate histologic evidence of a physical connective tissue attachment to the implant collar, there was, however, statistically significantly less CBL and greater CAL associated with the laser-microtextured implant collar in all the treatment categories. Therefore, these findings support the hypothesis that the laser-microtextured collar provides enhanced support to adjacent bone and connective tissue, regardless of the implant placement/loading protocol used. However, more long-term prospective and controlled clinical studies are needed to confirm the hypothesis of reduced marginal bone loss when implants with a laser-microtextured collar are used in immediate placement and/or immediate loading strategies.

In the present study, all patients underwent consistent professional periodontal maintenance during the entire observation period, and no signs of inflammation had been observed before patients with implant problems visited the office. The lack of a statistically significant difference between the failure rates of L and M implants could have been a result of the comparatively low overall failure rate, which may have prevented the detection of any statistically significant differences. Because of the considerably varied timing of failures (5 to 224 days), the limited number of failures, and the fact that this study did not differentiate between failure types, conclusions cannot be drawn correlating implant failure to the protocol or implant type. A limitation of the present study may lie in the fact that the treatment for each patient was not randomized because of the retrospective study design. Furthermore, the selection of implant type was based on the choices of the patient and, where applicable, the referring dentist.

CONCLUSION

Within the limits of this study, clinical and radiographic evaluation suggests that a laser-microtextured surface on the implant collar may mitigate or eliminate the negative sequelae associated with peri-implant bone loss, regardless of the timing of implant placement and loading used.

ACKNOWLEDGMENTS

The authors reported no conflicts of interest related to this study.

Table 4 Radiographic CBL Outcomes of 291 Implants

Time after loading	Implant type (no.)	Mean CBL (mm) vs baseline	
		Maxilla	Mandible
T1			
IP and INOL	LL (46)	−0.30	−0.34
	M (40)	−0.78	−0.71
IP and DL	LL (33)	−0.39	−0.35
	M (30)	−0.79	−0.76
DP and INOL	LL (43)	−0.33	−0.39
	M (34)	−0.76	−0.80
DP and DL	LL (37)	−0.38	−0.31
	M (28)	−0.80	−0.82
Total	LL (159)	−0.35	−0.34
	M (132)	−0.78	−0.77
T2			
IP and INOL	LL (46)	−0.12 (−0.42)	−0.04 (−0.38)
	M (40)	−0.23 (−1.01)	−0.26 (−0.97)
IP and DL	LL (33)	−0.02 (−0.41)	−0.02 (−0.37)
	M (30)	−0.19 (−0.98)	−0.14 (−0.90)
DP and INOL	LL (43)	−0.09 (−0.42)	−0.02 (−0.41)
	M (34)	−0.19 (−0.95)	−0.19 (−0.99)
DP and DL	LL (37)	−0.08 (−0.46)	−0.11(−0.42)
	M (28)	−0.22 (−1.02)	−0.16 (−0.98)
Total	LL (159)	−0.08 (−0.52)	−0.05 (−0.54)
	M (132)	−0.21 (−0.99)	−0.19 (−0.96)
T3			
IP and INOL	LL (46)	−0.01 (−0.43)	−0.03 (−0.41)
	M (40)	−0.03 (−1.04)	−0.09 (−1.06)
IP and DL	LL (33)	−0.06 (−0.47)	−0.06 (−0.43)
	M (30)	−0.15 (−1.13)	−0.15 (−1.05)
DP and INOL	LL (43)	−0.03 (−0.45)	−0.04 (−0.54)
	M (34)	−0.14 (−1.09)	−0.07 (−1.06)
DP and DL	LL (37)	−0.06 (−0.52)	−0.02 (−0.44)
	M (28)	−0.15 (−1.17)	−0.13 (−1.11)
Total	LL (159)	−0.04 (−0.57)	−0.04 (−0.59)
	M (132)	−0.12 (−1.10)	−0.11 (−1.07)

The variables of time of placement and/or loading showed no significant influence on general CBL outcomes between different time examinations. Spearman correlation: $R < 0.2$, $P > .05$.

REFERENCES

1. Andersen E, Haanaes HR, Knutsen BM. Immediate loading of single-tooth Straumann implants in the anterior maxilla: A prospective 5-year pilot study. Clin Oral Implants Res 2002;13:281–287.
2. Bornstein MM, Lussi A, Schmid B, Belser UC, Buser D. Early loading of nonsubmerged titanium implants with a sandblasted and acid-etched (SLA) surface: 3-year results of a prospective study in partially edentulous patients. Int J Oral Maxillofac Implants 2003;18:659–666.
3. Cochran DL, Buser D, ten Bruggenkate CM, et al. The use of reduced healing time on Straumann implants with a sandblasted and acid-etched (SLA) surface: Early results from clinical trials on Straumann SLA implants. Clin Oral Implants Res 2002;13:144–153.
4. Covani U, Crespi R, Cornelini R, Barone A. Immediate implants supporting single crown restorations: A 4-year prospective study. J Periodontol 2004;75:982–988.
5. Lorenzoni M, Pertl C, Zhang K, Wimmer G, Wegscheider WA. Immediate loading of single-tooth implants in the anterior maxilla. Preliminary results after one year. Clin Oral Implants Res 2003;14:180–187.
6. Luongo G, Di Raimondo R, Filippini P, Gualini F, Paoleschi C. Early loading of sandblasted, acid-etched implants in the posterior maxilla and mandible: A 1-year follow-up report from a multicenter 3-year prospective study. Int J Oral Maxillofac Implants 2005;20:84–91.
7. Nikellis I, Levi A, Nicolopoulos C. Immediate loading of 190 endosseous dental implants: A prospective observational study of 40 patient treatments with up to 2-year data. Int J Oral Maxillofac Implants 2004;19:116–123.
8. Quinlan P, Nummikoski P, Schenk R, et al. Immediate and early loading of SLA Straumann single-tooth implants: An in vivo study. Int J Oral Maxillofac Implants 2005;20:360–370.
9. Roccuzzo M, Bunino M, Priglio F, Bianchi S. Early loading of sandblasted and acid-etched (SLA) implants: A prospective split-mouth comparative study. Clin Oral Implants Res 2001;12:572–578.
10. Tarnow DP, Emtiaz S, Classi A. Immediate loading of threaded implants at stage 1 surgery in edentulous arches: Ten consecutive case reports with 1- to 5-year data. Int J Oral Maxillofac Implants 1997;12:319–324.
11. Schulte W, Kleineikenscheidt H, Schareyka R, Heimke G. Concept and testing of the Tuebingen immediate implant [in German]. Dtsch Zahnarztl Z 1978;33:319–325.

12. Barzilay I, Grasser GN, Iranpour B, Natiella JR. Immediate implantation of a pure titanium implant into an extraction socket: Report of a pilot procedure. Int J Oral Maxillofac Implants 1991;6:277–284.
13. Chen ST, Wilson TG, Hammerle CH. Immediate or early placement of implants following tooth extraction: Review of biologic basis, clinical procedure, and outcomes. Int J Oral Maxillofac Implants 2004;19(suppl):12–25.
14. Lazzara RJ. Immediate implant placement into extraction sites: Surgical and restorative advantages. Int J Periodontics Restorative Dent 1989;9:332–343.
15. Parel SM, Triplett RG. Immediate fixture placement: A treatment planning alternative. Int J Oral Maxillofac Implants 1990;5:337–345.
16. Schropp L, Kostopoulos L, Wenzel A. Bone healing following immediate versus delayed placement of titanium implants into extraction sockets. A prospective clinical study. Int J Oral Maxillofac Implants 2003;18:189–199.
17. Schwartz-Arad D, Chaushu G. The ways and wherefores of immediate placement of implants into fresh extraction sites: A literature review. J Periodontol 1997;68:915–923.
18. Werbitt MJ, Goldberg PV. The immediate implant: Bone preservation and bone regeneration. Int J Periodontics Restorative Dent 1992;12:206–217.
19. Schropp L, Isidor F. Timing of implant placement relative to tooth extraction. J Oral Rehabil 2008;35(suppl 1):33–43.
20. Schropp L, Kostopoulos L, Wenzel A, Isidor F. Clinical and radiographic performance of delayed-immediate single-tooth implant placement associated with periimplant bone defects. A 2-year prospective, controlled, randomized follow-up report. J Clin Periodontol 2005;32:480–487.
21. Weber HP, Morton D, Gallucci GO, Roccuzzo M, Cordaro L, Grutter L. Consensus statements and recommended clinical procedures regarding loading protocols. Int J Oral Maxillofac Implants 2009;24(suppl):180–183.
22. Brånemark PI, Engstrand P, Ohrnell LO, et al. Brånemark Novum: A new treatment concept for rehabilitation of the edentulous mandible. Preliminary results from a prospective clinical follow-up study. Clin Implant Dent Relat Res 1999;1:2–16.
23. Esposito M, Grusovin MG, Willings M, Coulthard P, Worthington HV. The effectiveness of immediate, early, and conventional loading of dental implants: A Cochrane systematic review of randomized controlled clinical trials. Int J Oral Maxillofac Implants 2007;22:893–904.
24. Hermann F, Lerner H, Palti A. Factors influencing the preservation of the periimplant marginal bone. Implant Dent 2007;16:165–175.
25. Maeda Y, Miura J, Taki I, Sogo M. Biomechanical analysis on platform switching: Is there any biomechanical rationale? Clin Oral Implants Res 2007;18:581–584.
26. Degidi M, Iezzi G, Scarano A, Piattelli A. Immediately loaded titanium implant with a tissue-stabilizing/maintaining design ('beyond platform switch') retrieved from man after 4 weeks: A histological and histomorphometrical evaluation. A case report. Clin Oral Implants Res 2008;19:276–282.
27. Pecora GE, Ceccarelli R, Bonelli M, Alexander H, Ricci JL. Clinical evaluation of laser microtexturing for soft tissue and bone attachment to dental implants. Implant Dent 2009;18:57–66.
28. Botos S, Yousef H, Zweig B, Flinton R, Weiner S. The effect of laser microtexturing of the dental implant collar on crestal bone levels and peri-implant health. Int J Oral Maxillofac Implants 2011;26:492–498.
29. Hermann JS, Schoolfield JD, Nummikoski PV, Buser D, Schenk RK, Cochran DL. Crestal bone changes around titanium implants: A methodologic study comparing linear radiographic with histometric measurements. Int J Oral Maxillofac Implants 2001 Jul–Aug;16(4):475–485.
30. Schwarz F, Herten M, Sager M, Wieland M, Dard M, Becker J. Histological and immunohistochemical analysis of initial and early osseous integration at chemically modified and conventional SLA titanium implants: Preliminary results of a pilot study in dogs. Clin Oral Implants Res 2007 Aug;18(4):481–488. Epub 2007 Apr 30.
31. Ellingsen JE. Surface configurations of dental implants. Periodontol 2000 1998 Jun;17:36–46.
32. Hamilton DW, Chehroudi B, Brunette DM. Comparative response of epithelial cells and osteoblasts to microfabricated tapered pit topographies in vitro and in vivo. Biomaterials 2007 May;28(14):2281–2293.
33. Weiner S, Simon J, Ehrenberg DS, Zweig B, Ricci JL. The effects of laser microtextured collars upon crestal bone levels of dental implants. Implant Dent 2008 Jun;17(2):217–228.
34. Ricci JL, Charvert J, Frenkel S, et al. Bone response to laser microtextured surfaces. In: Davies JE (ed). Bone Engineering. Toronto: Em2, 2000:282–294.
35. Alexander H, Ricci JL, Hrico GJ. Mechanical basis for bone retention around dental implants. J Biomed Mater Res B Appl Biomater 2007;23:200–210.
36. Nevins M, Kim DM, Jun SH, Guze K, Schupbach P, Nevins ML. Histologic evidence of a connective tissue attachment to laser microgrooved abutments: A canine study. Int J Periodontics Restorative Dent 2010 Jun;30(3):245–255.
37. Nevins M, Nevins ML, Camelo M, Boyesen JL, Kim DM. Human histologic evidence of a connective tissue attachment to a dental implant. Int J Periodontics Restorative Dent 2008 Apr;28(2):111–121.
38. Listgarten MA, Lang NP, Schroeder HE, Schroeder A. Periodontal tissue and their counterparts around endosseous implants. Clin Oral Implants Res 1991;2:1–19.
39. Schupbach P, Glauser R. The defense architecture of the human periimplant mucosa: A histological study. J Prosthet Dent 2007 Jun;97(6 suppl):S15–25 [erratum 2008 Mar;99(3):167].
40. Berglundh T, Lindhe J. Dimension of the periimplant mucosa. Biological width revisited. J Clin Periodontol 1996 Oct;23(10):971–973.
41. Hermann JS, Cochran DL, Nummikoski PV, Buser D. Crestal bone changes around titanium implants. A radiographic evaluation of unloaded nonsubmerged and submerged implants in the canine mandible. J Periodontol 1997 Nov;68(11):1117–1130.
42. Hermann JS, Buser D, Schenk RK, Higginbottom FL, Cochran DL. Biologic width around titanium implants. A physiologically formed and stable dimension over time. Clin Oral Implants Res 2000 Feb;11(1):1–11.
43. Quirynen M, Naert I, van Steenberghe D, Nys L. A study of 589 consecutive implants supporting complete fixed prostheses. Part I: Periodontal aspects. J Prosthet Dent 1992 Oct;68(4):655-63.
44. van Steenberghe D, Lekholm U, Bolender C, et al. Applicability of osseointegrated oral implants in the rehabilitation of partial edentulism: A prospective multicenter study on 558 fixtures. Int J Oral Maxillofac Implants 1990 Fall;5(3):272–281.
45. Richter EJ. Basic biomechanics of dental implants in prosthetic dentistry. J Prosthet Dent 1989 May;61(5):602–609.
46. Shapoff CA, Lahey B, Wasserlauf PA, Kim DM. Radiographic analysis of crestal bone levels around Laser-Lok collar dental implants. Int J Periodontics Restorative Dent 2010 Apr;30(2):129–137.
47. Bader J. Implant supported single crowns offer good 5-year survival, but with complications. J Evid Based Dent Pract 2008;8:232–233.
48. Jung RE, Pjetursson BE, Glauser R, Zembic A, Zwahlen M, Lang NP. A systematic review of the 5-year survival and complication rates of implant-supported single crowns. Clin Oral Implants Res 2008;19:119–130.
49. Abt E. Growing body of evidence on survival rates of implant-supported fixed prostheses. J Evid Based Dent 2008;9:51–52.
50. Zafiropoulos GGK, Deli G, Bartee BK, Hoffmann O. Single-tooth implant placement and loading in fresh and regenerated extraction sockets. Five-year results: A case series using two different implant designs. J Periodontol 2010;81:604–615.
51. Ericsson I, Nilson H, Nilner K, Randow K. Immediate functional loading of Brånemark single tooth implants: An 18-month clinical pilot follow-up study. Clin Oral Implants Res 2000;11:26–33.
52. Hui E, Chow J, Li D, Liu J, Wat P, Law H. Immediate provisional for single-tooth implant replacement with Brånemark System: Preliminary report. Clin Implant Dent Relat Res 2001;3:79–86.
53. Calandriello R, Tomatis M, Vallone R, Rangert B, Gottlow J. Immediate occlusal loading of single lower molars using Brånemark System wide-platform TiUnite implants: An interim report of a prospective open-ended clinical multicenter study. Clin Implant Dent Relat Res 2003;5(suppl 1):74–80.

54. Malo P, Rangert B, Dvarsater L. Immediate function of Brånemark implants in the esthetic zone: A retrospective clinical study with 6 months to 4 years of follow-up. Clin Implant Dent Relat Res 2000;2:138–146.
55. Rocci A, Martignoni M, Gottlow J. Immediate loading in the maxilla using flapless surgery, implants placed in predetermined positions, and prefabricated provisional restorations: A retrospective 3-year clinical study. Clin Implant Dent Relat Res 2003;5(suppl 1):29–36.
56. Chaushu G, Chaushu S, Tzohar A, Dayan D. Immediate loading of single-tooth implants: Immediate versus nonimmediate implantation. A clinical report. Int J Oral Maxillofac Implants 2001;16:267–272.
57. Malo P, Friberg B, Polizzi G, Gualini F, Vighagen T, Rangert B. Immediate and early function of Brånemark System implants placed in the esthetic zone: A 1-year prospective clinical multicenter study. Clin Implant Dent Relat Res 2003;5(suppl 1):37–46.
58. Quirynen M, Van Assche N, Botticelli D, Berglundh T. How does the timing of implant placement to extraction affect outcome? Int J Oral Maxillofac Implants 2007;22(suppl):203–223.
59. Ricci JL, Grew JC, Alexander H. Connective-tissue responses to defined biomaterial surfaces. I. Growth of rat fibroblast and bone marrow cell colonies on microgrooved substrates. J Biomed Mater Res A 2008 May;85(2):313–325.
60. Grew JC, Ricci JL, Alexander H. Connective-tissue responses to defined biomaterial surfaces. II. Behavior of rat and mouse fibroblasts cultured on microgrooved substrates. J Biomed Mater Res A 2008 May;85(2):326–335.
61. Shin S-Y, Han D-H. Influence of microgrooved collar design on soft and hard tissue healing of immediate implantation in fresh extraction sites in dogs. Clin Oral Implants Res 2010;21:804–814.