Comparative Evaluation of Laser-microtextured Implant Versus Machined Collar Implant for Soft and Hard Tissue Attachment: A Clinical and Radiological Study

Abstract

Background: Various mechanical modifications in the collar region of endosseous implants is a challenge for better performance and osseointegration. Here is a comparative evaluation being carried out to find out the effect of the machined collar (MC) and Laser-Lok (LL)-modified titanium implants on the success of implants being commonly advocated in partially edentulous among serving personnel and their families. Materials and Methods: Twenty-four patients with appropriate inclusion and exclusion criteria were selected for placement of Biohorizons MC and LL implants in 12 cases each. Aseptic surgical procedure was followed for implant surgery, and clinical parameters such as clinical attachment loss, pocket depth (PD), bleeding on probing, and plaque index (PI), mobility parameters estimated by Periotest value, and radiographic assessment of crestal bone loss (CBL) at interval of 6 months and 1 year were recorded and compared by statistical analysis. Results: Intragroup comparison at 6 and 12 months period for all the parameters were nonsignificant except CBL in Group A (CBL-MC) with 12 cases shows a mean of 0.917 and 1.500, respectively, standard deviation difference = 0.477 (significant) with \( P < 0.05 \). Similar significant difference in CBL was observed with superior result in LL implants. Conclusion: The presence of LASER textured with microgrooves on the collar of the implants did not increase the PI and sulcular bleeding index. The probing PD was much less as observed in the group of LASER-treated implants in comparison with that of MC group. LL implant had an edge over MC proving success of the laser treatment on collars of implants.

Keywords: Crestal bone loss, laser-Lok, machined collar

Introduction

Placement of endosseous implants has become an option in the comprehensive periodontal treatment plan for both fully and partially edentulous patients. Implant-supported restorations are positioned in relation to esthetics, function, and speech instead of neutral zone of soft tissue support[1] Over the last decade, reconstruction with dental implants has changed considerably.

In recent years, a series of studies have demonstrated that implant design characteristics micrograph or interface (the space between implant components, such as the implant and abutment) and rough/smooth implant border (the border between rough and smooth implant surfaces) and the placement technique in relation to the crest of the bone have clinically significant influences on peri-implant crestal bone levels[2-4] soft tissue dimensions (biologic width).[7-9] According to standard surgical procedures, the smooth collar of rough-smooth implant bordered implants should be aligned with the crest of the bone and adjacent to peri-implant soft tissues.

Polished and machined collars (MCs) have been advocated for dental implants to reduce plaque accumulation and crestal bone loss (CBL). More recent research has suggested that a roughened titanium surface promotes osseointegration and connective tissue attachment. Titanium alloy dental implants have been designed, fabricated, and tested with microgeometries (surface characteristics in the micron range) to control bone and soft-tissue integration. These surfaces have highly oriented, consistent microstructures that are applied using computer-controlled laser ablation techniques using a pulsed, computer-controlled excimer LASER system, and large area masking. Animal experiments indicate that this technology...
enhances bone and soft-tissue integration and controls the local microstructural geometry of attached bone.[10]

LASER-Lok (LL) microchannels is a proprietary dental implant surface treatment developed from over 20 years of research initiated to create the optimal implant surface. The unique LL surface has been shown to elicit a biologic response that includes the inhibition of epithelial down growth and the attachment of connective tissue (unlike Sharpey fibers).[11]

The purpose of this research was to evaluate soft tissue and hard tissue attachment of LASER microtextured geometric design in osseointegrated period using clinical and radiological periodontal parameters and also to facilitate the choice of dental implant in the management of edentulous area thereby allowing prudent utilization of funds and facilities in the Armed Forces.

Materials and Methods

Twenty-four patients complying inclusion and exclusion criteria were selected after obtaining consent to participate in this study. These patients were divided equally into two groups, namely, Group A and Group B of twelve patients each by random sampling. Two implant systems were used in this study. They are (1) implant with an MC (Biohorizon Tapered internal implant) in Group A and (2) implant with a LASER-microtextured collar (Biohorizons LASER microdesign internal dental implant LL) in Group B patients.

Inclusion criteria

• Eighteen years of age and above
• One bounded edentulous space, i.e., a single missing tooth with intact proximal teeth with sufficient bone quality and quantity to allow for implant placement [Figure 1]
• Irrespective of sex should have a good systemic health without any systemic disease
• Patients should be cooperative, motivated and hygiene conscious.

Exclusion criteria

• Systemic disease possibly affecting the healing process, for example, diabetes mellitus and smokers
• Metabolic bone disease
• Treatment with therapeutic radiation to head within past 12 months
• Pregnancy
• Severe bruxism or clenching habit
• Active infection or severe inflammation in the areas intended for implant placement
• Absence of keratinized tissue at implant site
• Need for antibiotic prophylaxis or postoperative antibiotic coverage
• Need for simultaneous hard and soft tissue grafting
• Unable or unwilling to comply with study procedures and visits.

A verbal and written informed consent was taken from patients. Initial therapy was performed on all patients, which consisted of full-mouth scaling and root planing using hand and ultrasonic instrumentation. The various laboratory investigations were carried out for all the patients in both the groups which included complete blood count, prothrombin time, international normalized ratio, blood sugar, and urine examination.

A customized acrylic stent was fabricated for each patient and stored on the study cast to minimize distortion. The stent was grooved in an occlusal-apical direction with a tapered bur so that the periodontal probe was returned to the same position on each successive measurement.

The following clinical and radiological parameters were recorded at 6 months and 12 months of osseointegration period postoperatively after placement of dental implants. They are pocket depth (PD), clinical attachment loss (CAL), plaque index (PI), sulcular bleeding index (SBI), and implant stability.

Radiographic assessment and measurements

Radiovisiographs (RVG) were taken for all the selected sites having implants following a standardized technique. To facilitate radiographic measurements, a metallic mm grid/mesh with 1 mm markings was used, which was placed on the sensor during exposure to X-rays. The details of peri-implant bone loss were analyzed on computer attached with RVG. CBL was taken as the average of the 2 radiographic measurements taken at the mesial and distal locations of the implant.

Surgical procedure

The patient was draped in a sterile manner, anesthetized with 2% lidocaine using 1:100,000 epinephrine. Patients were prepared for surgery in accordance with accepted dental practice guidelines, and implant surgeries were performed on an outpatient basis. Full-thickness flaps were elevated with a horizontal incision to reveal the

Figure 1: Partial edentulous area
bone surface after administration of local anesthetics. Biohorizons LASER microdesign Internal dental implant LL 3.5 × 10.5 mm, 4 × 10.5 mm, and 4 × 12 mm, and Tapered internal implant (MC) of various dimensions were used in the ongoing study [Figures 2 and 3]. Vertical incisions were used as necessary for visibility. Implant osteotomies were prepared according to the manufacturer’s guidelines, and the implants were placed. Primary flap closure was obtained with nonresorbable black silk sutures. Postoperative digital periapical radiographs were made using a paralleling technique to record the exact bone level at baseline. Patients were instructed not to brush or floss at the surgical sites until suture removal 7-day postoperative. They were also instructed to rinse with 0.2% chlorhexidine mouthwash daily for 1 week and were prescribed appropriate antibiotics and analgesics. Routine postoperative evaluations were conducted until the time of stage 2 surgery and abutment connection. Cover screws were replaced with healing abutments using a punch technique if adequate keratinized gingival was present around the facial aspect of the implant. Sites with an inadequate zone of gingiva, a full-thickness mucoperiosteal flap were elevated to place healing abutments, and the flap was repositioned apically to create a wider zone of gingiva. A postoperative digital periapical radiograph was then taken [Figure 4]. The mean time from the initial placement surgery to healing abutment connection was 4.8 months. At the end of implant protocol, the appropriate prosthesis was given to the implants.

The various clinical and radiological parameters were assessed at the time interval of 6 months and 1 year [Figures 5 and 6]. The data so collected were tabulated and subjected to statistical analysis. Student’s paired and unpaired t-test were used for intragroup and intergroup comparison. The software used in the analysis was Systat version 8.1 (Systat Software Inc. is a wholly-owned subsidiary of Cranes Software International Limited).

Results

An equal number of MC implants were placed both in maxilla and mandible whereas 5 and 7 LL implants were placed on maxilla and mandible, respectively [Table 1].

The various clinical parameters for intragroup comparison after 6 and 12 months of implant placement included probing PD (PPD), PI, SBI, and CAL. The RVG value of CBL was considered as radiological parameter, and Periotest value was taken for assessment of implant mobility.

Intragroup comparisons at 6 and 12 months in machine collar and Laser-Lok implants

Table 2 depicts the intragroup and intergroup comparison of PPD in between Group A and B at 6 and 12 months interval.

A maximum of 4 mm of peri-implant PD was observed in an MC implant at 12-month interval. Paired samples
Table 1: Intergroup comparisons of demographic data

| Variables       | MC (Group A) | LL (Group B) |
|-----------------|--------------|--------------|
| Males           | 7            | 6            |
| Females         | 5            | 6            |
| Maxillary       | 6            | 5            |
| Mandibular      | 6            | 7            |

MC = Machined collar, LL = Laser-Lok

Table 2: Means of clinical parameters

| Clinical parameters | Duration (months) | MC (Group A) | LL (Group B) |
|---------------------|-------------------|--------------|--------------|
| Probing depth       | 6                 | 2.083        | 1.500        |
|                     | 12                | 2.167        | 1.666        |
| Plaque index        | 6                 | 0.083        | 0.167        |
|                     | 12                | 0.167        | 0.208        |
| Bleeding index      | 6                 | 0.250        | 0.208        |
|                     | 12                | 0.208        | 0.160        |
| CAL                 | 6                 | 1.741        | 1.083        |
|                     | 12                | 1.500        | 0.160        |

MC = Machined collar, LL = Laser-Lok, CAL = Clinical attachment loss

difference = 0.289, \( t = 1.000 \) Deg of freedom = 11, Prob = 0.339, Dunn-Sidak Adjusted Prob = 0.339 (not significant) with \( P > 0.05 \) [Table 2]. Similar test on PPD-LL with 12 cases at 6 and 12 months interval shows a mean at 6 months 1.500, mean at 12 months 1.667, mean difference = −0.167 shows a nonsignificant value with \( P > 0.05 \) [Table 2].

Six and 12 months interval PI for MC and LL Group B (PI-LL) with 12 cases in each shows statistical nonsignificant results with \( P > 0.05 \) [Table 2].

Paired samples \( t \)-test on 6 and 12 months interval for SBI in Group A (SBI-MC) and Group B with 12 cases depicts not significant with \( P > 0.05 \).

On the contrary, CAL in Group A (CAL MC) at 6 and 12 months interval with 12 cases shows mean = 1.500 and 2.833, respectively, with mean difference = −1.333, 95.00% CI = −1.897–−0.769, SD difference = 0.888, \( t = 5.204 \) df = 11, Prob = 0.005, Dunn-Sidak Adjusted Prob = 0.002 (significant) with \( P < 0.05 \).

Statistical analysis (paired samples \( t \)-test) on 6 and 12 months CAL in Group B (CAL-LL) with 12 cases shows mean = 1.083 and mean = 1.250, respectively, with mean difference = −0.167, 95.00% CI = −0.508–0.174, SD difference = 0.537, \( t = 1.076 \) df = 11, Prob = 0.305, Dunn-Sidak Adjusted Prob = 0.305 (not significant) with \( P > 0.05 \).

Paired samples \( t \)-test from data analysis from Table 2 on 6 and 12 months CBL in Group A (CBL-MC) with 12 cases shows a mean of 0.917 and 1.500, respectively, and mean difference = −1.000, 95.00% CI = −1.303–0.697, SD difference = 0.477, \( t = 7.266 \) df = 11, Prob = 0.012, Dunn-Sidak Adjusted Prob = 0.010 (significant) with \( P < 0.05 \).

Paired samples \( t \)-test on 6 and 12 months CBL and Periotest mobility value in Group B (CBL-LL) with 12 cases in each group were statistically nonsignificant.

Intergroup comparisons between machine collar and Laser-Lok at 12 months

Unpaired samples \( t \)-test was performed to compare Group A versus Group B for PPD with 12 cases which shows a mean = 2.167 and mean = 1.667 with mean difference = 0.500, 95.00% CI = −0.135–1.135, SD difference = 1.000, \( t = 1.732 \) df = 11, Prob = 0.111, Dunn-Sidak Adjusted Prob = 0.101 (not significant) \( P > 0.05 \) [Table 2].

Twelve-month PI comparison between Group A and B indicates a mean difference of −0.042, SD difference = 0.582, \( t = −0.248 \), Dunn-Sidak Adjusted Prob = 0.809 (not significant) with \( P > 0.05 \) [Table 2].
The nonsignificant result was also observed while comparing SBI and CAL between Group A and B at 12 months.

Unpaired samples t-test on Group A and B for CBL with 12 cases shows a mean of 2.833 and 1.917, respectively, with mean difference = 0.917, SD difference = 1.084, t = 2.930, df = 11, Prob = 0.014, Dunn-Sidak Adjusted Prob = 0.014 (significant), p < 0.05 [Table 3].

**Discussion**

The current case–control study was undertaken to compare the effectiveness of MC and LL implants for studying the soft tissue attachment and osseointegration around the implants. The results of the study indicate that LL treatment on the collar of the implant surface gives better results for both hard and soft tissue attachment to the implant surface. These data indicate that there is no increase in these inflammation measures (bleeding and plaque indices) as compared with either prospective controls or historical data.

The consistent difference in probing depth between the implant pairs with and without the LASER microtexture surface treatment implies that a soft-tissue seal above the bone has been established in the LL implanted sites. This was demonstrated histologically in a previous canine implant study. Accounting for the CBL with both implants, a −1.0–0.7 mm probing difference is maintained throughout the study. This is approximately the height of the texturing (0.7 mm) on the LL implant.

The CBL data are the most dramatic result of this study. The LL bone loss is limited to 0.59 mm whereas the control data demonstrate up to 1.94 mm of bone loss. The data reported for other implant systems are in the range from 1.0 to 2.5 mm.[13-15] The LL surfaced implant is superior in this important measure to consecutive controls and literature reports on other implant systems.

The study proved that microtexturing with LASER on the collar portion of the implant results in stronger and higher crestal bone attachment adjacent to the implant. This may be due to the fact that the mechanical substrate adjacent to the bone has tremendous influence on the cell growth and development.[10] The integrins are the structures present on the cell surface which usually bridges the cell-to-cell, which gets modified by the surface modifications of implant collar region. Ultimately, this change also affects on the internal structure of the cell.[17] LASER has an effect on modification of precursors of the cell, for example, fibroblast and osteoblast. Tissue culture study has proved that effective cells attachment increases to the LASER textured implant surface.[19] The consistent difference in probing depth between LL and control implant demonstrates the formation of a stable soft-tissue seal above the crestal bone. LL limited the CBL to the 0.59 mm range as opposed to the 1.94 mm CBL reported for control implant. LL microchannels is a series of cell-sized circumferential channels that are precisely created using laser ablation technology. This technology produces extremely consistent microchannels that are optimally sized to attach and organize both osteoblasts and fibroblasts.[10] The LL microstructure also includes a repeating nanostructure that maximizes surface area and enables cell pseudopodia and collagen microfibrils to interdigitate with the LL surface.

**Conclusion**

The presence of LASER textured with microgrooves on the collar of the implants did not increase the PI and SBI. The PPD was much less as observed in the group of LASER-treated implants in comparison with that of MC group. Statistically significant amount of peri-implant bone loss was seen surrounding the MC implants postoperatively at 1 year, and a significant difference was noted if compared with LASER-treated implants. The future of dental implantology should aim at developing surfaces with controlled and standardized topography or chemistry. These therapeutic strategies should ultimately enhance the osseointegration process of dental implants for their long-term success.

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**Conflicts of interest**

There are no conflicts of interest.

**References**

1. Iacono VJ; Committee on Research, Science and Therapy, the American Academy of Periodontology. Dental implants in periodontal therapy. J Periodontol 2000;71:1934-42.
2. Abrahamsen I, Berglundh T, Lindhe J. The mucosal barrier following abutment dis/reconnection. An experimental study in dogs. J Clin Periodontol 1997:24:568-72.
3. 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;68:1117-30.
4. Hermann JS, Buser D, Schenk RK, Cochran DL. Crestal bone changes around titanium implants. A histometric evaluation of

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**Table 3: Means of radiological parameters**

| Radiological parameters | MC (Group A) | LL (Group B) |
|-------------------------|--------------|--------------|
| Crestal bone loss (months) | 6 | 1.500 | 0.917 |
|                          | 12 | 2.833 | 1.250 |
unloaded non-submerged and submerged implants in the canine mandible. J Periodontol 2000;71:1412-24.

5. Hermann JS, Schoolfield JD, Numnikoski 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;16:475-85.

6. Hänggi MP, Hänggi DC, Schoolfield JD, Meyer J, Cochran DL, Hermann JS. Crestal bone changes around titanium implants. Part I: A retrospective radiographic evaluation in humans comparing two non-submerged implant designs with different machined collar lengths. J Periodontol 2005;76:791-802.

7. Cochran DL, Hermann JS, Schenk RK, Higginbottom FL, Buser D. Biologic width around titanium implants. A histometric analysis of the implant-gingival junction around unloaded and loaded nonsubmerged implants in the canine mandible. J Periodontol 1997;68:186-98.

8. 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;11:1-11.

9. Hermann JS, Buser D, Schenk RK, Schoolfield JD, Cochran DL. Biologic width around one- and two-piece titanium implants. Clin Oral Implants Res 2001;12:559-71.

10. Ricci JL, Charvet J, Frenkel SR. Bone response to laser microtextured surfaces. In: Davies JE, editor. Bone Engineering. Ch. 25. Toronto, ON: EM2 Inc.; 2000.

11. Nevins M, Nevins ML, Cameo M, Boyesen JL, Kim DM. Human histologic evidence of a connective tissue attachment to a dental implant. Int J Periodontics Restorative Dent 2008;28:111-21.

12. 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;17:217-28.

13. Ricci G, Aimetti M, Stabulum W, Guasti A. Crestal bone resorption 5 years after implant loading: Clinical and radiologic results with a 2-stage implant system. Int J Oral Maxillofac Implants 2004;19:597-602.

14. Bryant SR, Zarb GA. Crestal bone loss proximal to oral implants in older and younger adults. J Prosthet Dent 2003;89:589-97.

15. Heydenrijk K, Raghoebar GM, Meijer HJ, Stegenga B. Clinical and radiologic evaluation of 2-stage IMZ implants placed in a single-stage procedure: 2-year results of a prospective comparative study. Int J Oral Maxillofac Implants 2003;18:424-32.

16. Brunette DM. The effects of implant surface topography on the behavior of cells. Int J Oral Maxillofac Implants 1988;3:231-46.

17. Dalby MJ, Childs S, Riehle MO, Johnstone HJ, Affrossman S, Curtis AS. Fibroblast reaction to island topography: Changes in cytoskeleton and morphology with time. Biomaterials 2003;24:927-35.

18. Inoue T, Cox JE, Pilliar RM, Melcher AH. Effect of the surface geometry of smooth and porous-coated titanium alloy on the orientation of fibroblasts in vitro. J Biomed Mater Res 1987;21:107-26.