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Comparative evaluation of hard and soft tissue parameters by using short and standard dental implants for prosthetic rehabilitation of posterior mandible: a split mouth study

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ABSTRACT

Aim The length of fixtures is always standardized with the concept for better bone to implant contact and successful osseointegration. Lots of studies have justified the use of short implants of less than 10 mm as an alternative for resorbed ridges in maxilla and mandible. The present project was conducted to check the viability of short implants in complex prosthetic rehabilitations.

Materials and methods Eleven patients received a total of 18 short implants (3.3/6 mm - 4.2/9.5mm) and 18 standard implants (3.75/11 mm and 4.5/11.5 mm) in the posterior mandible. Marginal bone loss was evaluated immediately after the delivery of the prosthesis, then after 3, 6, 12 and 18 months. Same measurements were done for standard implants as the study design was split mouth.

Results The survival rate of short implants 18 months after prosthesis delivery was 94.4% and it was 100% for standard implants. There was no significant difference between implants at the time intervals of 6 and 18 month's post-delivery of crowns and bridges. Mean crestal bone loss was 1.77±0.22 mm and 2.03±0.21 mm for short and standard implants respectively at 18 months of follow up, which was statistically significant. One short implant failure was seen before the loading of prosthesis.

Conclusion Short implants may be considered as an alternative for complex augmentation procedures in mandible and maybe in maxilla too. Patient should be educated before for the reduced survival rate of short implants compared to standard implants.

KEYWORDS Bone augmentation; Crestal bone loss; Long Implants; Short implants.

INTRODUCTION

Dental implant therapy is widely accepted by patients and dentists as a reliable method for oral rehabilitation. There are, however, a number of anatomic and clinical factors that should be considered to gain predictable results and to avoid complications. This, in turn means that several conditions have to be evaluated when implant therapy is planned, such as oral health, absence of acute oral pathology, systemic disorders, smoking status, presence of sufficient keratinized mucosa, and, above all, the presence of sufficient bone volume. When volume is not sufficient for implant prosthetic rehabilitation, different solutions are available to augment bone, such as for instance onlay and inlay bone grafts, maxillary sinus elevation, guided bone regeneration, ridge expansion, or distraction osteogenesis, all of which involve prolonged healing time, higher morbidity, and higher costs (1). As an alternative solution, the use of short implants to compensate for resorbed ridges may be considered as a viable alternative for successful prosthetic rehabilitation (2,3). In the past short implants were associated with higher failure rates because of reduced bone to implant contact ratio. Higher crown to implant ratio due to extensive resorption also complicated the biomechanics. Recent literature has demonstrated no significant differences in the survival rate of short and standard implants. Different lengths have been suggested to define an implant as being "short: <10 mm (4,5,6,7,) ≤8 mm (8) or ≤6 mm (9). The recent advancements in modified implant designs, different microtopography and surface coatings might have contributed for increased survival rate of short implants.

The present study was thus conducted to compare short implants with standard size implants in resorbed partially edentulous mandibles using a split mouth design followed by the prognosis of prosthesis and marginal bone loss measurements.

MATERIALS AND METHODS

Eleven patients attending the OPD of the Faculty of

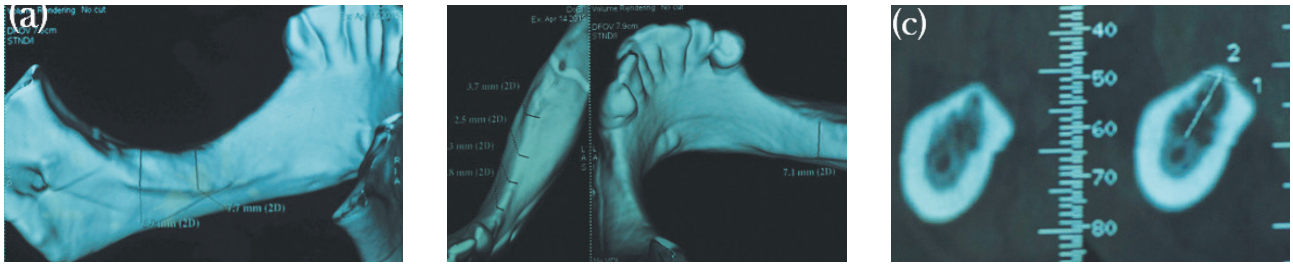

FIG. 1 Dentascan images showing edentulous area bilaterally in the mandible.

Dental Science BHU, Varanasi, INDIA of age 25 to 45 years fulfilling the inclusion and exclusion criteria were selected for the study. The test group consisted of sites which were treated with short implants and control group comprised of sites with standard implants in a split mouth design that is if the short implants were placed on the right side, the standard implants were placed on the left side or vice versa. The sites to be treated with short or standard implants were decided by a lottery method. A total of 18 short implants (3.3/6 mm till 4.2/9.5 mm) and 18 standard implants (3.75/11 mm and 4.5/11.5 mm) were placed on the 36 edentulous sites. The principles of the study were according to Helsinki declaration (2013), where the well being of the subjects, privacy and safeguarding was of prime importance than the results of the study. The patients were informed prior that any adverse problems during the course of the study would be well taken care of. Research was based on the standard protocols with well established procedures and was conducted by scientifically qualified personnel under medical supervision. The patient was free to withdraw from the study at any stage of the treatment procedure without this, in any condition, affecting further treatment. The patients were asked to sign a consent form in front of a witness who also countersigned the consent form. The approval for the study design was obtained from the Institute Ethical Committee (Ref nu.: ECR/526/Inst/UP/2014 Dt 31.1.14). The total time duration of the study was from Februrary 2014 to December 2017. Consort guidelines were followed.

Sample size was determined by the formula

$N = z^2 . \delta^2 / (x1-x2)^2$

$Z = 1.96$

δ = pooled standard deviation(= 0.72)[8]

X1=mean of group 1 (= 0.86)

X2= mean of group 2 (=0.45)

Substituting these values in the above formula a sample size of 11.84 was obtained. To deal with anticipated drop outs a sample size of 18 implants was taken.

'Short' implant was defined as less than 10 mm, and standard size was more than or equal to ten mm. Implant and prosthesis failure, peri-implant marginal bone loss, technical along with biological complications were analyzed. The clinical and radiographic data of thirty six short and standard implants of bilateral posterior missing teeth in mandible were evaluated.

The following inclusion criteria were applied.

1 Age25 to 45 years.
2 Partial edentulism bilaterally in the posterior region in the mandible (Fig. 1).
3 Favorable intermaxillary relationship and adequate bone volume on implant site radiographically.
4 Free from periodontal diseases.

Exclusion criteria were as follows.

1 General contraindication to implant surgery.
2 Subjected to irradiation.
3 Under chemotherapy for malignant tumor.
4 Improper oral hygiene.
5 Uncontrolled diabetes.
6 Pregnant or lactating women.
7 Substance abuser.
8 Acute infection in the area intended for implant patients.
9 Extraction site with less than 3 months of healing.

Procedures

Each patient with bilateral missing posterior teeth in mandible with optimum reduced ridge was prepared for either short or standard implants. The surgery was completed on both sides in a single procedure. A maximum of six implants were placed in one sitting in an individual. The surgical areas were anesthetized with infiltration of lignocaine (Lignox 0.2%) along with adrenaline 1:80000 bilaterally. Surgical stent (Easy Vac Gasket) were used to optimize implant positions. The incisions were full thickness with maximum preservation of keratinized gingiva. Drills with stops and increasing diameter were used to prepare implants osteotomy as per manufacturer instructions (Xive Implants, Dentsply For Standard Implants, India, Alpha Dent India For Short Implants). After the placement of implants, sutures of porcine origin were used in a crisscross manner to close the flap (Vicryl 4-0 suture Ethicon, Johnson and Johnson) (10). Periapical radiographs (baseline) were made with paralleling technique (RVG - Vtech EZ 1.5 Sensor Classic, Rinn XCP). Patients medical prescription included Amoxicillin and clavulanic acid 625 mg twice daily along with Ibuprofen 400 mg four times for seven days starting thirty minutes before implant placement

with additional twice daily chlorhexidine (0.12%w/v) rinses till the removal of sutures. Patients were given appropriate instructions of oral hygiene maintenance on the surgical site along with a soft diet for one week. No removable prosthesis was allowed on the treated areas for three weeks (Fig. 2). Intra and post-operative experiences were recorded for each subject on a 10 point VAS scale where 0 signified "definitely no" whereas 10 was for "definitely yes" for both intra operative experiences and prosthetic considerations (11,12). just after implant placement, 2 weeks after implant placement and at the time of occlusal loading.

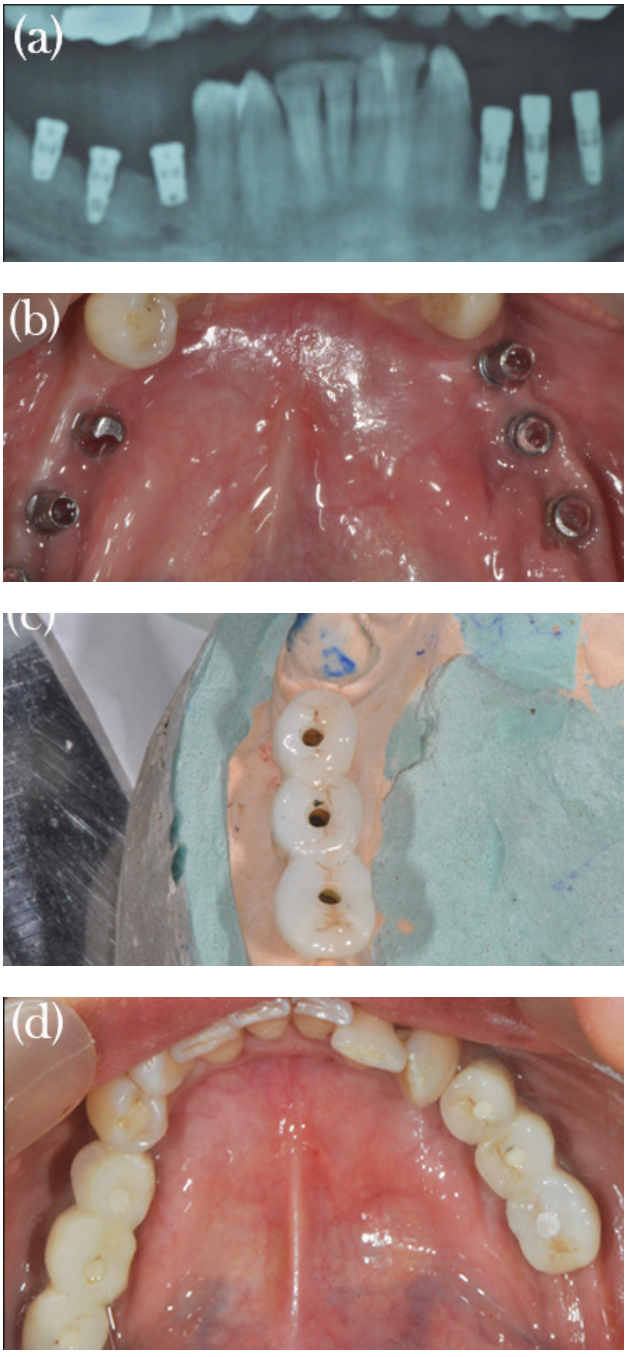

FIG. 2 Three implants placed bilaterally on each side, short on left side, standard on right side (a). Baseline radiograph (b). Clinical view of prosthesis bilaterally (c). Picture showing the screw retained prosthesis (d).

Prosthetic

Three months after implant placement, each implant was evaluated radiographically (OPG) and mechanical stability was confirmed with Implant Stability Quotient (Ostell, Sweden). Impressions with pickup copings were taken using addition silicone (DENTSPLY, Aquasil). Abutments of adequate length with or without splinting were customized. The crowns (IPS e max, Ivoclar Vivadent) fabricated had narrow occlusal table, flat contours and designed hygienically in case of bridges. Occlusion with the antagonistic dentition was kept in such a way that the forces were always directed in axial direction without any lateral contacts in excursions and no contacts posteriorly during anterior guidance (Fig. 3). Periapical radiographs (baseline) were made with paralleling technique (RVG, Vtech EZ 1.5 Sensor Classic, Rinn XCP) (13). Radiographs of short and standard implants were evaluated for the distance between the implant shoulder and the bone/implant contact point at the mesial and distal surfaces using a computerized image-analysis system(Adobe Photoshop CS, San Jose CA; Digital Subtraction Radiography), and the average value was obtained. Bone measurements were evaluated by single independent examiner at the time of delivery of prosthesis and every six months till the completion of 18 months (intra operator reliability = 0.85).

Data was entered in microsoft excel sheets and analysed by SPSS software version 19 (IBM Corp. Released 2010.

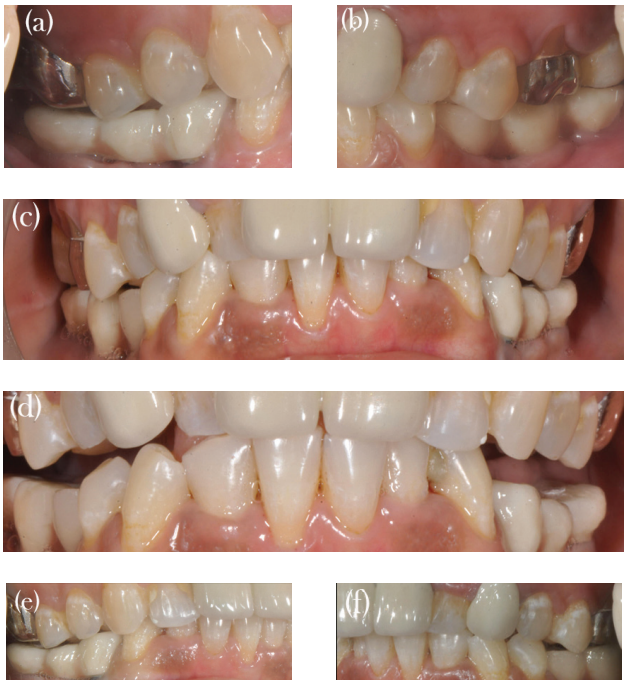

FIG. 3 Prosthesis occlusion in all movements

Length of implant (mm)	number	%	Length of implant(in mm)	number	%
6	6	33.33	11	15	83.3
8	10	55.55	11.5	3	16.6
9.5	2	22.22			

TABLE 1 Length distribution of implants among study population.

Mean VAS score	Number of patients	
	Short implant group	Standard implant group
9	9 (81.81%)	8 (72.72%)
7	2 (18.18%)	2 (18.18%)
6	0 (0)	1 (9.09%)

TABLE 2 Distribution of study population according to the readings of Visual Analogue Scale.

	Short implant group	standard implant group	p-value
PPD 1	2.35±0.28	2.43±0.75	0.37
PPD 2	2.47±0.36	2.49±0.76	0.53
PPD 3	2.5±0.64	2.53±0.47	0.41
PPD 4	2.53±0.73	2.53±0.56	0.79

PPD1 = Peri-implant probing depth at the time of loading
PPD2 = Peri-implant probing depth at 6 months
PPD3 = Peri-implant probing depth at 12 months
PPD4 = Peri-implant probing depth at 18 months

TABLE 3 Mean peri-implant probing depth (PPD) at each follow up (in milimeters).

IBM SPSS Statistics for Windows, Version 19.0. Armonk, NY: IBM Corp) by an independent statistician who was unaware of the methodology and concepts of the study. Descriptive statistical analysis was done. t test was used to compare the mean probing depths and mean crestal bone loss between two sites. To compare VAS scores Mann Whitney U test was used.

RESULTS

A total of 15 subjects (9 males and 6 females) aged 25 to 45 years with bilateral edentulous spaces were screened for this split mouth study. Four subjects did not fulfill atleast one of the inclusion criteria, hence were excluded from the study. A total of 18 short and 18 standard size implants were placed in the remaining 11 subjects in a split mouth design where one side was treated with short implants and the other with standard implants. Lottery method was used to decide the site selection for each group of implants (Table 1). The study period was from February 2014 to December 2017 with regular checkups at 3 months, 6 months, 12 months including an 18 month follow up for all patients with no further dropouts from the study. All of the implants placed in the present study were in the posterior mandible.

Intraoperative experiences and prosthetic considerations were recorded using the VAS (Visual Analogue Scale) just after implant placement, 2 weeks after implant placement and at the time of occlusal loading. The cumulative VAS score was then divided by three to obtain a mean value for each individual. Maximum number of subjects recorded 9 on a scale of 1 to 10. A VAS score of 9 for group 1 was recorded by 9 subjects while 2 recorded 7. Interestingly, in the standard implant group also a VAS score of 9 was recorded in 8 subjects, whereas 2 gave score 7 and 1 gave a score of 6 (Table 2). The results of the study showed no clinically or statistically significant changes between both sites, rather the subjects registered a more positive response. Peri-implant probing depth between the two groups had no significant differences. The values of probing depth ranged from 2-4 mm in both groups, with a mean value of 2.35±0.28 in group 1 and 2.43±0.75 in group 2 at the time of prosthesis insertion. At the 18-month follow up the mean probing depths were 2.53±0.73 and 2.53±0.56 mm respectively (Table 3).

The mean crestal bone loss at the time of occlusal loading was 1.44 mm and 1.53 mm in short and standard implants respectively. The difference was statistically not significant. The standard implant group consistently registered more crestal bone loss as compared to the short implants after six, twelve, and 18months of occlusal loading and the results were found to be statistically significant (Fig. 4, 5, Table 4).

No difference in implant survival rate was noticed for both groups. The short implant group registered an implant survival rate of 94.4%, whereas no implant failure was registered for the standard implant group within the study period after surgery or after functional occlusal loading. One implant in the short implant group was lost before functional loading due to reasons which could not be adequately determined.

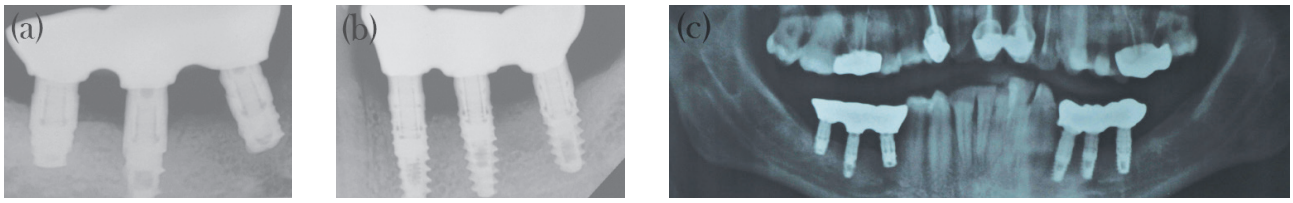

FIG. 4 Radiographs of prostheses at 6 months.

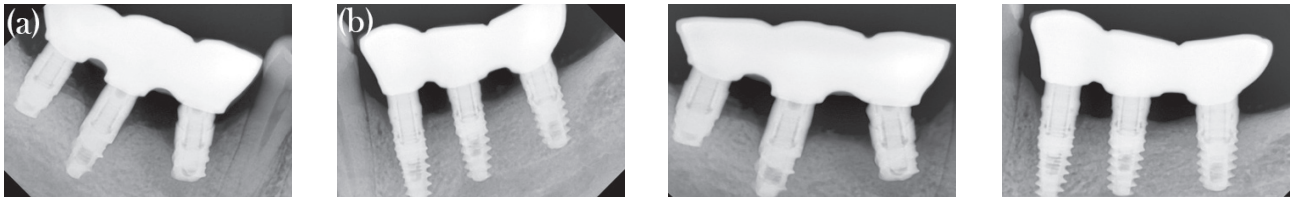

FIG. 5 Radiographs of prostheses at 18 months.

	MEAN		
	Short implant group	standard implant group	p-value
CBL 1	1.44±0.20	1.53±0.16	0.09
CBL 2	1.55±0.21	1.71±0.19	0.002
CBL 3	1.70±0.23	1.86±0.20	0.005
CBL 4	1.77±0.22	2.03±0.21	<0.001

CBL1 = Crestal bone loss at the time of prosthesis delivery (base line)
CBL2 = Crestal bone loss at 6 months
CBL3 = Crestal bone loss at 12 months
CBL4 = Crestal bone loss at 18 months

TABLE4 Mean peri-implant probing depth (PPD) at each follow up (in milimeters).

DISCUSSION

The purpose of this clinical study was to evaluate the survival and marginal bone changes of 18 short and 18 standard implants placed in bilaterally partial edentulous mandible. A split mouth design was chosen as it eliminates any possibility of inter-individual variability for result estimation.

The length of the short implants placed in this study ranged between 6 and 9.5 mm with the highest number of 8 mm implants. All the implants gave promising results and were in function during the course of the study, including the 6 mm implants. A skeptical attitude prevails over the success of the short implants particularly 6 mm ones. Gulje et al. (14) successfully rehabilitated a patient with four 6 mm implants with extremely resorbed mandible with bar retained overdentures and were of the opinion that these short implants served as an excellent base for prosthetic rehabilitation. It is a widely believed fact that the length of implants has a positive effect on the success of dental implants, however Lee et al. (15) found no linear relationship between the length of implants and their success rates.

The survival rate for short implants placed in the present study was 94.4% with no relevant side effects like pain, paresthesia or infection, clearly demonstrating the biocompatibility and safety of short dental implants which may delineate their validity and predictability in the rehabilitation of edentulous atrophied mandibular ridges. The surgical protocols and follow up visits were similar for all the patients and all the implants, putting to rest any controversies arising from different implant systems or procedures followed. Controversial results have been reported with the use of short dental implants, but these differences may be attributed to various factors which affected implant outcome like the experience and skill of the surgeon, type of implants, bone quality and quantity, prosthetic protocols and the lack of a uniform definition of short implants (16). Individualized treatment planning, use of adequate surgical protocols better surface treatments of implants, better technologies and adequate hydrodynamic cooling may enhance the outcome in all cases. High survival rates of short implants specially in the posterior mandible have been documented in several studies (17,18,19). Christer Slotte et al. (20) reported that 4 mm long titanium implants with the SLA active surface could be successfully placed in severely resorbed posterior mandible with healthy peri-implant conditions for at least 5 years.

Success of implants is a multivariable dependent parameter. Surface treatment of implants and moderately rough surface may increase the success of short implants as compared to the earlier machined surfaces (6,20). With increased bone contact percentage

there is a decreased stress to the bone implant interface. The short dental implants used in the present study had rough surfaces with maximum number of threads, thus increasing the bone implant contact area, producing favorable results. These can be corroborated by the studies of Anitua et al. (16) and Misch et al. (4), who also reported the surface design and condition of implants to be an important criterion for their success.

The biomechanics associated with implant supported prosthesis well documents the use of short implants (21). After successful osseointegration, when an implant is loaded the maximum stress concentration is found around the first few threads to the crestal cortical bone, thus rendering implant diameter a more important parameter than implant length (21). This has also been supported by Javed et al. (22), who reported implant diameter to be of paramount importance for implant success. However, in the present study, both narrow and wide diameter implants were incorporated and both gave evenly successful results. This may be attributed to the force distribution by splinting of the implants and maintaining no lateral contacts. This is in accordance with the findings of Pommer et al. (6) who reported that narrow diameter implants do not suffer from higher risk of failure when compared to standard implants. From the biomechanical stand point, it has also been reported the disadvantage associated with crown implant ratio concerning the short implants. However several studies with long follow up of increased ratio of crown on short implants have proved that marginal bone loss is negligible, as the stress after loading of prosthesis is at the crest of the implant and length does not matter but the crown height should not be more than 15 mm (23,24), because it creates a vertical cantilever. By simply increasing the crown height from 10 to 20 mm, the force on the implants gets increased by 100% (25). Previous literature on animal studies have demonstrated that occlusal loads lead to increase marginal bone loss 26. It has also been described that micromovements in the range of 100-200 micrometers may inhibit bone growth and increase the risk for implant loss (27). In the present study there were no biological complications; the most prevalent issue reported was peri-mucositis around the implants which was resolved through professional oral prophylaxis measures alone and did not progress to peri-implantitis until the completion of this study period. Implant success has also been documented to be dependent on optimized implant surgical protocols and prosthetic replacements, like splinting implants, avoiding cantilever, using maximum number of implants and eliminating lateral contacts (4).The high success rate attained in the present study supports these theories.

Values of crestal bone levels were recorded after loading of prosthesis at the interval of 6, 12 and 18 months for both groups. Marginal bone loss in the short implant group was less as compared to long implant group at all follow up visits and there was statistically significant difference between the two groups. Interestingly, maximum mean bone loss was 1.44±0.20 mm for short implants and 1.53±0.16 mm for standard implants from the time of surgery to prosthesis delivery. Eighteen months after prosthesis delivery it was 1.77±0.22 mm for the short implant group and 2.03±0.21 mm for the standard implant group. The difference became statistically significant at 18 months of study. The short implants were placed at a subcrestal level, while the placement of standard implants was equicrestal or subcrestal according to individual cases. This may explain the slightly increased values of mean crestal bone loss in the standard implant group. These findings are in accordance with the results from the studies of Fickl et al. (28), Herman et al. (29), Pontes et al. (30), and Singh et al. (31) who also reported that implants placed at subcrestal levels showed less bone loss as compared to implants placed at equicrestal levels.

A complication faced in this study was the early failure of one short implant before prosthesis loading; the standard implants were successful in all the patients. Annibali et al. (7) also reported that most short implants failed before prosthesis placement as was found in the present study. Bruggenkate (32) conducted a multicenter study of short dental implants. They placed 253 short implants 6 mm long of which 7 implants failed, it is remarkable to note that out of these seven, six were placed in the maxilla. Grunder (33) in his study reported a higher failure rate for short implants in the posterior region of the maxilla, especially when periodontitis was cited as a reason for tooth extraction. Over a period of 3 years, the implant survival rate was reported to be 92.4% in the maxilla and 94.7% in the mandible. Thoma (34) reported an implant survival rate of 100% for short implants in his comparative study between long and short implants. However it is advised to use a two stage protocol for the success of short implants (35).

Short dental implants provide an upper hand in terms of surgical protocols since they reduce the need for bone and sinus augmentation procedures. The risk of sinus perforation or mandibular paresthesia is also minimized leading to simple and convenient surgical maneuvers. Short dental implants provide the surgeon with a decreased risk of overheating of bone, decreased manipulations of bone, reduced need of office inventory and overhead expenses. To the patient short dental implants offer reduced treatment cost, treatment time and discomfort. However the risk factors should be well evaluated for each case individually in terms of diagnosis, treatment planning, surgical protocols and number of implants, biomechanics and occlusion protocols in order to gain the best possible results (4). The results of the present study are also well supported by the literature review done by Ciarmatori et al. (36), who concluded that short implants could be considered as a treatment option comparable to traditional length implant.

Limitations of present study

The limitation of our study is that radiographic measurements were done using Radiovisiography (RVG) which gave only two dimensional data. Precise CT scan (3D) analysis of bone levels could have given more accurate and undistorted results, however it carries risk of radiation overexposure. Also, clinical conditions around the implants placed in the present study were not the same as there were differences in the quality and quantity of bone. The sample size was small and a longer follow-up period would have been desirable. The results of this study can be corroborated with increased sample size and conducting randomized control trials in the future.

CONCLUSION

The survival rate of short implants in the present study was 94.4% with a mean crestal bone loss of 1.77±0.22 mm 18 months after prosthesis delivery. These results well demonstrate that treatment with short implants is a reliable procedure and can be successfully used for rehabilitation of posterior partial edentulism keeping in mind the biomechanical and surgical protocols. However long term follow up and a larger sample size are required to further validate and confirm these findings.

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