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TITLE: IMPLANT PLACEMENT IN CONJUNCTION WITH RIDGE SPLIT AND EXPANSION TECHNIQUE

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ABSTRACT:

Aim: The aim of this study was to evaluate the efficacy of Ridge Split Technique and expansion technique to analyze peri-implant hard tissue changes following implant placement.

Material and method: A prospective study was conducted at Swami Devi Dyal Hospital &DentalCollege, Panchkula, India, from 2015-2017 on 10 patients, having at least 1-3 teeth missing, with a crestal width of at least 3mm and an 8mm apico-coronal height (3mm×8mm) from major anatomical structures.

Result :Out of the ten patients in whom the inclusion criteria met, 6 were male and 4 were female. Out of a total of 20 implants inserted,(13 implants in mandible and 7 in maxilla), healing was uneventful in all cases with no major complication. The mean

bone width bucco-lingually preoperatively was found to be 3.79 ±0.36 mm, and bucco-lingual width recorded immediately after RST was found to be and 6.38 ±0.51mm. This difference in bone width was found to be significant (p=.000). Also, a significant correlation was seen (p=0.003), further strengthening the results obtained.

Conclusion: Within the limits of our study, placing implants with simultaneous ridge splitting can reduce the period of edentulism and reduces the duration of treatment with excellent results. Though it is an operator dependant technique, and it cannot increase the vertical height of the ridge, still Ridge Split and Expansion technique is the best method for augmentation and simultaneous implant insertion in case of narrow ridges with minimum morbidity and less treatment duration

INTRODUCTION

Rehabilitation of partial or total edentulism with dental implants has been established as a predictable treatment modality with high success rates.[1] To enable long-term optimal functional and aesthetic results in dental implant therapy sufficient width and height of bone is mandatory at the recipient site. Clinical and radiographic studies have shown significant alteration in height and width of alveolar ridge following tooth extraction. There is vertical and horizontal bone loss after tooth extraction in maxilla and mandible. More rapid bone resorption is seen on buccal side than on lingual/palatal aspect of ridge. 40-60% of labial bone is lost during first three years after extraction and this loss continues at the annual rate of 0.25-.0.5% thereafter.[2,3] Major challenges in implant dentistry arises since alveolar atrophy always occurs subsequent to tooth extraction, periodontal disease or trauma which compromises the success of endosseous implants. This bone loss may jeopardize the implant placement in a prosthetically driven position with respect to position and angulation.

Malpositioned implant may affect the emergence profile of final prosthesis and may create problems in function and esthetics which may affect the long term success of implant.[4] The present perspective is to place an implant in a prosthetically driven position, so several methods have been described to augment the alveolar crest before or after implant placement to establish at least 1 mm bony wall around screw type implant. Traditional methods for bone augmentation includes onlay and inlay bone grafts, sandwich osteotomies, guided bone regeneration, and alveolar distraction osteogenesis. Although these methods are effective, they require long periods for bone consolidation prior to implant placement and create a possible morbidity at the donor site, risk of membrane exposure, unpredictable rate of resorption of grafting material and infection as postoperative complications .[5-7]An alternative surgical procedure, Ridge Split Technique (RST), has been developed for augmentation of atrophied alveolar process horizontally/bucco-lingualy. Historically, one of the first uses of ridge splitting was reported by Tatum between the end of the 1960s and the beginning of the 1970s[8] .The ridge splitting technique involves a longitudinal osteotomy on the residual ridge with the use of hand instrument, microsaw or ultrasonic device.[9,10] A controlled greenstick fracture is created and the alveolar ridge is split into two parts. Osteotomes, chisels, horizontal spreaders or screw spreaders can be used for ridge expansion and lateral repositioning of the buccal bone plate in order to create a wider implant bed. The intrabony defect between the two bone plates is filled spontaneously with newly formed bone similarly to the healing procedure of an extraction socket.[11] Compared with guided bone regeneration or bone grafting, the ridge splitting technique enables simultaneous implant placement, eliminates the need for bone harvesting and reduces the risk of graft or membrane exposure. Therefore, the overall treatment time is shortened and morbidity is reduced.[12-15] Various modifications of this procedure have been proposed. Osborn (1985)[15] suggested mobilizing the whole buccal bone plate, also using releasing osteotomies. Nentwig[16](1986) reported a

bone crest division technique that simultaneously allowed expansion of the alveolar crest and insertion of the implants. Simion(1992) reported a ridge-split technique with the use of PTFE (poly tetrafluoro ethylene) membrane to cover the expanded zone,[17] while Summers(1994) proposed the use of customized cylindrical and tapered osteotomes to perform his ridge expansion osteotomy. In this technique, after ridge splitting at crestal area, the space is opened with Summer osteotomes which generates room in the newly formed crest for implant placement.[18] The space between the separated buccal and lingual/palatal bone plates is filled with biomaterials like autologous grafts or autologous biological therapies, such as Platelet Rich Fibrin (PRF). PRF have been found to enhance the wound healing.[19,20] The advantages of the RST over the other methods of the ridge augmentation promoted the current study. The purpose of this study was to evaluate the efficacy of Ridge Split and expansion technique to analyze peri-implant hard tissue changes following implant placement.

MATERIALS AND METHOD

A prospective study was conducted at Swami Devi Dyal Hospital &Dental College, Panchkula, India, from 2015-2017 on 10 patients, age 18-60 years having at least 1-3 teeth missing, having a crestal width of at least 3mm and an 8mm apico-coronal height (3mm×8mm) from major anatomical structures, were selected from those reporting to the Department of Oral and Maxillofacial Surgery. The patients included in the study gave an informed consent. The study design had been approved by review committee of Pt. B.D. Sharma University of Health Sciences Rohtak. Preoperative detailed medical history of patient was recorded. Patient‘s clinical examination and radiological interpretation was done and for the proper evaluation of the ridge width, patients were advised to get Cone Beam Computed Tomography(CBCT). Patients with a history of smoking, drug or alcohol abuse,

severe bruxism, history of radiotherapy in the head and neck region for malignancies, bisphosphonate therapy, those requiring sinus lift, uncontrolled diabetes and/or hypertension, were excluded from the study.

STUDY DESIGN

This was a prospective case series study, there were total 8 clinical visits per patient during study.

First visit included panaromic radiograph and a detailed explanation of the study including the study procedures and required post-operative follow-up visits. Subjects completed a questionnaire to assess age, gender, medical history, dental history, history of tobacco use and current medications. Eligible patients enrolled in the study read and signed an informed consent. Study cast was also obtained in each case.

On **second visit**, labiolingual width of edentulous ridge was assessed using CBCT.(Fig 1) This initial CBCT analysis also was used to compare clinical alveolar ridge width measurement obtained at the time of surgery by using surgical calipers. On **third visit**, RST procedure was performed with immediate implant placement. Before flap elevation, clinical photographs and measurements related to soft tissue was taken. Measurement of the width of edentulous ridge prior to RST and following implant placement was performed after minimal full thickness flap elevation. Surgical caliper was used to measure the width approximately1mm below the crestal margin.

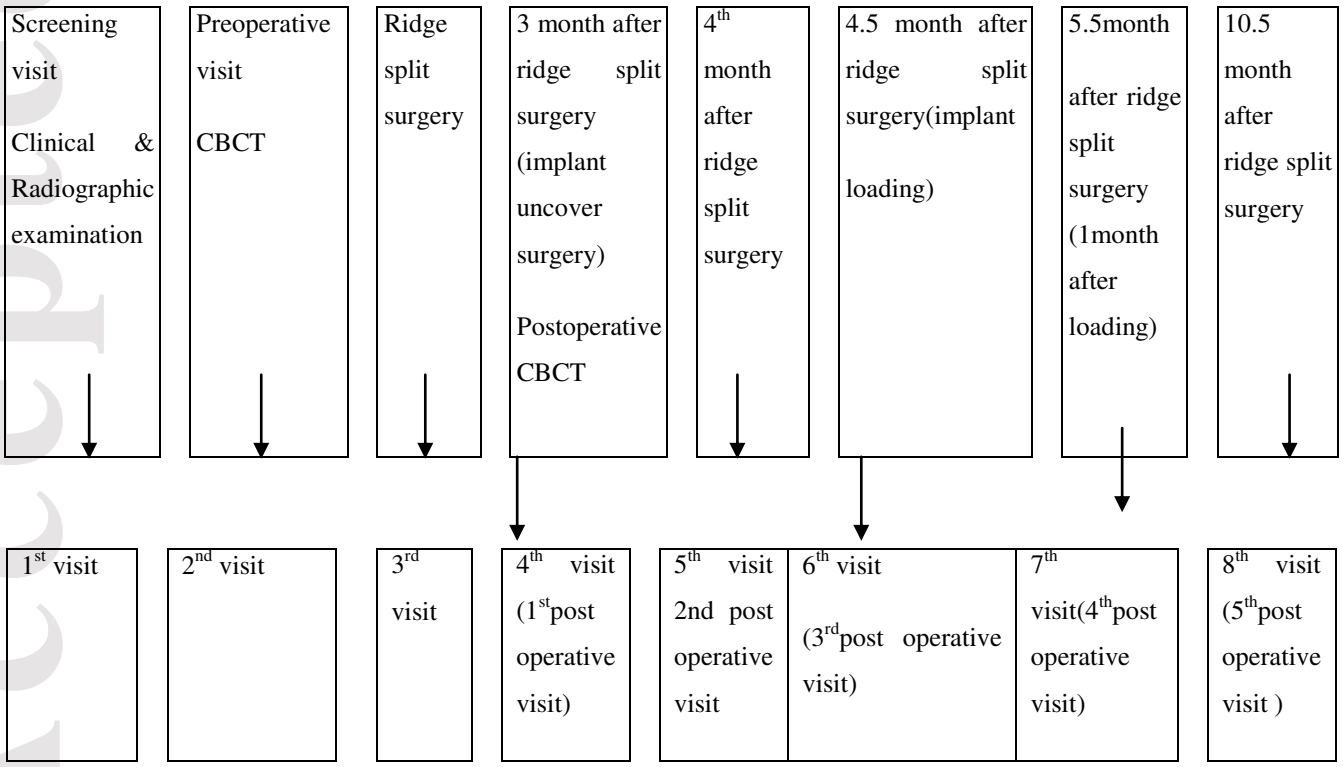
RIDGE SPLIT TECHNIQUE (SURGICAL PROCEDURE) All the patients were pre-medicated with amoxicillin 500 mg three times a day, starting 1 day preoperatively and for a total of 7 days. Patients were asked to rinse their mouth with chlorhexidine 0.12% twice daily

starting 1 day preoperative and for the first 2 weeks postoperative.The patients received 1 g amoxicillin 1 hour prior to surgery. Surgery was carried out under local anaesthesia using Xylocaine 2% containing 1:100000 epinephrine. A full thickness incision was made at crestal level on keratinized tissue. The incision extended to the next tooth or at least 5 mm more anterior or posterior from the end of the osteotomy planned, securing direct observation of the alveolar crest. Minimum deperiostization was performed in the vestibular area to obtain visibility of the operating site and subsequent recognition of any alteration in the implant installation. However in cases where a vertical bony cut had to be made on buccal cortex, mucoperiosteal reflection was done to vestibular depth. Anterior and posterior releasing incisions were given as needed

Bone incision (Fig.2) was made over the crest using microsaw, by using ESSET (Excellent/Easy Stable Split Expanding & Tapping) kit (©2012, Osstem Implant Co., Ltd.) (Fig.3) In some cases vertical incisions were also performed to avoid a malfracture of the osteotomized bone.(Fig.4) Dialator drills (Fig. 5) were used at a speed of 20 rpm and torque of 50 N-cm to expand the space for implant placement. In order to reduce the risk of fracture specific sequence of instruments were used to expand the alveolar ridge. The primary stability of implant was obtained with precise preparation of apical part of the implant site where the bone distraction was not performed and assigned surgical burs were used. Root form endosteal implant (Fig.6) with diameter ranging from 3.5mm-5.5mm was placed depending upon mesio-distal space and bucco-lingual bone thickness. Torque achieved was noted. 10 ml of venous blood of patient was withdrawn and PRF was prepared and placed into the expanded ridge. In most of the cases tension free approximation was achieved by 3-0 silk sutures without the need of periosteal releasing incision; wherever necessary periosteal releasing incision was performed to extend the flap coronally over the implant so as to

achieve tension free close approximation. Implant location compared to alveolar crestal bone level was documented with periapical radiographs.

Patient was discharged with instruction of good oral hygiene maintenance, Dietary limitations, systemic antibiotics for 7 days, Non steroidal anti-inflammatory drug for 3-5 days and 0.12% chlorhexidine mouthwash for 2 weeks. Sutures were removed on 10th post-operative day. On **4th** visit, after 3 months, implant uncovery surgery was performed. Measurements related to hard tissue conditions at RST site were repeated. Alveolar ridge measurement was repeated. Finally periapical radiographs were taken. The baseline and final peri-implant marginal bone level was determined by using a Standardized transparent mm ruler. Clinical and radiographic measurements (Fig.7) were done on **5th, 6th, 7th and 8th** visits at specific time period during study.



PATIENT VISIT TIMELINE CHART

OBSERVATIONS AND RESULTS

Out of the ten patients in whom the inclusion criteria met, 6 were male and 4 were female patients with their age ranging from 18- 60 years. Out of a total of 20 implants inserted, healing was uneventful in all cases with no major complication such as dehiscence of soft tissue or any loss of implants. Out of 20 implant, we had placed 13 implants in mandible and 7 implants in maxilla. The mean bone width bucco-lingually preoperatively was found to be 3.79±0.36, and bucco-lingual/palatal width recorded immediately after RST was found to be and 6.38 ±0.51 (Table 1). This difference in bone width was found to be significant (p=.000). Table2 describes the torque achieved while placing the 20 implants. The range of torque achieved was from 22-30 N-cm. Changes in radiographic bone width (CBCT) pre-surgically and after 3 months post implant insertion is depicted in table 3. It was revealed that the mean B/L radiographic (CBCT) bone width pre-surgically was 3.58±0.48 mm, which changed to 6.43±0.44 mm postoperatively. This difference in bone width was found to be significant (p=.000). Table 4 reveals radiographic alveolar crest bone loss around the implants in mm at defined time intervals throughout the investigation. The results highlighted that the mean radiographic alveolar crest bone loss (mesial/distal) at 3 months was 0.43±0.17mm, which changed to 0.48±0.15 mm at the time interval of 5.5 months. This difference in alveolar crest bone loss was not found to be significant at any stage of comparison (Table 5)

DISCUSSION

The objective of ridge augmentation is to increase the height and width of the ridge so as to rehabilitate endentulism with fixed implant supported prosthesis. Plethora of clinical approaches have been developed to increase the width/height of the alveolar ridges to fulfill the requirement of implant placement in atrophic ridges. The RST procedure in combination

with immediate implant placement has been described more than 20 years ago.[17,21] The main goal that has been achieved with ridge splitting was the gain of bone width with simultaneous implant insertion and integration. Careful preparation of the bone and maintenance of an attached periosteum are critical to the formation of new bone around the interproximal surfaces of the implants At least 3mm of the residual ridge is needed for the ridge splitting technique because cancellous bone must exist between cortical bone plates for bone expansion.[22] To maintain the vitality of the separated buccal bone plate through the ridge splitting procedure, an adequate blood supply is essential. If the blood supply from buccal periosteal flap and endosteal blood supply to the split buccal bone plate are blocked at the same time, the resorption of the buccal bone plate may be unavoidable even though a bone graft is applied into the furrow area. Thus, for successful clinical outcomes, it is necessary to minimize the amount of full-thickness flap reflection on the buccal side[23] as we did in our study. Blood supply from the periosteum allows for osseous tissue to develop, which eventually leads to the formation of lamellar bone.[24] The ridge split procedure was easier to perform in the maxilla due to the quality of bone without any need for vertical bony incisions .Clinical outcome of RST in maxilla are predictable because of the presence of the spongy medullary bone. The physical features of medullary bone include elasticity and flexibility; and these properties allows atraumatic expansion.[21] Even though it was easier to perform ridge split procedure in the maxilla, expansion was achieved equally in the mandible in our study The classic ridge split procedures involved razor sharp bone chisels and rotating or oscillating saws. Bone chisels are impacted into the bone with the use of a mallet, requiring precision and technical skill. In addition, rotating or oscillating saws are dangerous to both bone and soft tissue.[25] ESSET KIT was used in this study, making the split crest procedure less technically challenging and reducing the overall learning curve. It was initially developed in 2002 by Dr. B.H. Suh. Compared to standard sagittal osteotomy, where the

expansion of the atrophied site is obtained with chisels, expansion using the ESSET technique may allow a more gradual widening of the ridge and avoid excessive vestibular inclination of the fixture; there is also less risk of fracture of the osteotomized segments. In fact, traditional bone-splitting techniques[26] present problems associated with the fact that the axis of rotation is situated at the apical end of the osteotomy with consequent excessive vestibular inclination of the implant body. But in case of the ESSET kit expansion there is uniform expansion of the prepared osteotomy, so there are less chances of the buccal bone fracture and the emergence profile of the implant is maintained. Compared to conventional ridge splitting methods (i.e., mallets and chisels) the ESSET Kit's specialized tools safely and predictably split and expand the crestal bone, preparing the site to readily accept dental implants. The patient will experience a significant reduction in recovery time, with the process ensuring minimal bone fracture and high initial stability, while the practitioner will be able to save time and money using a simple, safe, and predictable procedure with an easy-to-use ridge split technique Another observation encountered in this study was the critical care that must be taken when using the implant twist drills for site preparation following the ridge split procedure. The lateral part of the twist drill could easily fracture and move the labial plate due to its speed and torque. It could also perforate the labial/palatal apical aspects of the cortical plates. The ridge expansion procedure allowed the widening of the coronal and middle aspects of the ridge, but the apical part maintained the same initial width. Implant twist drill with appropriate angulation was crucial during site preparation. Several authors advocated different ridge split technique, in which crestal cut osteotomy is joined to adjacent vertical osteotomy cut on either or on both side.[17,26] In the present study out of 20 implant placed in 10 patients, 11 implants were in posterior region of the mandible and to prevent the fracture of the of the buccal wall in one case both mesial and distal releasing bone cut were placed, in 2 cases only mesial cut in the buccal bone was given. In one of the case in maxilla

there was buccal bone dehiscence and block grafting was done. Autogenous bone graft was harvested from the symphysis region. This was however not included in the statistical analysis.

The main complication of ridge-splitting, however, is the complete fracture of the cortical plate, which leads to problems with perfusion. The risk of malfracture of the osteotomized segment is high in the mandible due to thicker cortical plates.[5,16,27] To avert an undesired fracture, therefore, in our study we did a combined ridge split with expansion osteotomy to expand and compress the split plates gradually and simultaneous implant placement. It must be considered that during the ridge expansion using the bone chisels and osteotomes, only the buccal cortical plate of the maxilla/mandible is displaced in a labial direction. The lingual/palatal cortical plates are stronger and are not weakened during the expansion. The cortices follow the path of least resistance which is towards the labial aspect. In 2000, Spray et al. recommended that a buccal plate 1.8~2mm should be left after preparation of the site for the reduction of the loss of facial bone around the dental implant.[28] Sandwich-bone augmentation was therefore adopted, the inter-cortical space was filled with bone grafts, and a buccal plate more than 1.8mm thick was achieved, which ensured the long-term stability of the peri-implant hard and soft tissue. Such material provides a scaffold that both prevents the collapse of the cortical plates and accelerates healing. In our study we used PRF (Platelet Rich Fibrin) to fill the osteotomised site and to fill the space between the lateralized buccal and lingual plates. The PRF membrane acts as a healing material accelerates wound closure by acting as a fibrin bandage. The leukocytes concentrated in the PRF scaffold hold antiinfectious properties. The platelet concentrates secrete the growth factors which are protected from proteolysis by the fibrin network, the growth factors promote cell migration and matrix remodeling during healing period.[29] In our study the mean gain in bucco-lingual /palatal width preoperatively and immediate postoperatively was found to be 2.59 ±0.15 and

the mean bucco-lingual/palatal width gain radiographically preoperatively and three month postoperatively found to be 2.93 ±0.36 respectively. Blus et al[10] performed the RST with immediate placement in both maxillary and mandibular sites. Two hundred thirty implants were placed with an increase in bone width ranging from 2.5 – 4.0 mm. Original reports by Simion et al[16] and Scipioni et al[26], in 1992 and 1994, respectively, demonstrated an alveolar width gain between 1 and 4 mm after the split-crest procedure and successful immediate implant placement and osseointegration (success rate of 98.9%). Ostman et al[30] found primary stability to be dependent on the jaw, bone density, gender, implant diameter and the anterior/posterior position of the implant. Interestingly, Ostman et al found decreasing stability with increasing implant length. However no such finding were present in our study, all implants placed showed good implant stability with insertion torque of > 20 N-cm. In our study there was early crestal bone resorption around the implant initially which is stabilized and there was negligible bone loss at crestal level further. This was measured by VixWin Pro 2000, Gendex Imaging. The survival rates of implants immediately placed in expanded sites ranged from 91% to 97.3%, while the success rates varied from 86.2% to 98.8%.[28] Success/survival rate in our study could not be judged since the maximum follow up period was only 1 year after loading.

Within the limits of our study, placing implants with simultaneous ridge splitting can reduce the period of edentulism and reduces the duration of treatment with excellent results.

The commonest complications associated with the surgery are wound dehiscence, inadvertent fracture of the labial plate during manipulation and extensive resorption of the labial bone during the healing phase.[7] Though it is an operator dependant technique, and it cannot increase the vertical height of the ridge, Ridge Split and Expansion technique is one of the alternative method for augmentation and simultaneous implant insertion in case of narrow ridges with minimum morbidity and decreased treatment duration. However it is

recommended that a study involving a larger sample size with a follow up of at least 5 years should be undertaken to arrive at a definitive conclusion.

Declaration

Competing Interests

NONE

Please state any sources of funding for your research

NONE

Please state whether Ethical Approval was given, by whom and the relevant Judgement's reference number

Yes, ethical approval had been taken from Ethical Committee of Pt. B.D. Sharma University of Health Sciences

Clinical Relevance section

Scientific rationale for study; Traditional methods for bone augmentation although effective, require long periods for bone consolidation prior to implant placement. Ridge split technique overcomes the drawbacks of these methods and provides a simple and viable alternative.

Principal findings: The ridge splitting technique seems to be a minimally invasive option for horizontal augmentation of narrow alveolar ridges with adequate height which enables immediate implant placement and eliminates morbidity and overall treatment time.

Practical implicatios: Ridge split procedure provides a cost effective and minimally invasive technique for management of horizontally deficient ridges

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Figure Legends

Figure 1- Preoperative CBCT of the patient

Figure 2- Bone incision using microsaw

Figure 3- ESSET KIT

Figure 4- Vertical bone incision

Figure 5- Dilator drill in position

Figure 6- Implants placed at ridge split and expandeed alveolar ridge

Figure 7- Postoperative CBCT of the patient

Table Legends

Table 1- Ridge width: Pre operative and immediate postoperative

Table 2- Torque achieved (N-cm) during implant insertion after RST

Table 3- Radiographic ridge width : Presurgical and 3 month postoperative

Table 4- Crest bone loss around the implants (mesial/distal) in mm (Vixwin pro 2000, Gendex imaging)

Table 5- Crest bone loss (RBL) around the implants (mesial/distal) in mm

PATIENT	IMPLANT SITE	CLINICAL MEASUREMENT (surgical caliper) B/L WIDTH(mm) Pre-op	CLINICAL MEASUREMENT (surgical caliper) B/L WIDTH(mm) Post-op	Significance (t-test), Spearman's correlation
1	35	4	6.5	
	36	3.9	6.5	
	37	3.8	6.5	
2	35	4.5	7	**Paired Samples t-test**
	36	4.5	7	
3	21	3	5.5	t= -29.455
	23	3.5	5.5	sig=.000
4	21	3.5	6	
5	46	3.3	6.5	
	47	3.4	6.5	**Spearmans's Correaltion**
6	24	4	6	
	25	3.8	5.5	r=.624
7	45	3.9	6.5	Significance= .003*
	46	4	7	
8	41	3.8	7	
	31	4	7	
9	15	3.8	6.5	
	16	3.9	6.5	
10	45	3.6	6	
	46	3.5	6	
Mean Pre-operative and Immediate Post-Operative Bone Loss (mean ±SD)		**3.79±0.36**	**6.38±0.51**	

Table 1 Pre surgical ridge width and immediate postoperative ridge width after RST

PATIENT	IMPLANT	TORQUE ACHIEVED
1.	35	27
	36	25
	37	26
2.	35	27
	36	26
3.	21	22
	23	25
4.	21	24
5.	46	28
	47	29
6.	24	27
	25	27
7.	45	30
	46	30
8.	41	25
	31	23
9.	15	21
	16	25
10	45	24
	46	28

Table 2 Torque achieved during implant insertion after RST

PATIENT	IMPLANT SITE	RADIOGRAPHIC(CBCT) MEASUREMENT B/L WIDTH(mm) PRE-OPERATIVE	RADIOGRAPHIC(CBCT) MEASUREMENT B/L WIDTH(mm) AFTER 3 MONTHS	Significance (t-test), Spearman's correlation
1	35	3.79	5.75	
	36	3.79	7.27	
	37	3.79	7.27	
2	35	4.34	6.92	**Paired Samples t-test**
	36	4.34	6.82	
3	21	2.44	5.87	t= -29.887
	23	2.44	5.97	sig=.000
4	21	3.44	5.92	
5	46	3.25	6.43	
	47	3.29	6.32	**Spearmans's Correaltion**
6	24	3.75	6.22	
	25	3.73	6.43	r=.511
7	45	3.83	6.38	
	46	3.8	6.44	Significance = .021*
8	41	3.72	7	
	31	3.7	6.4	
9	15	3.63	6.45	
	16	3.62	6.43	
10	45	3.4	6.4	
	46	3.42	6	
Mean Pre-operative and Immediate Post-Operative Bone Loss (mean ±SD)		**3.58±0.48**	**6.43±0.44**	

Table 3 Radiographic (CBCT) width presurgical and after 3 months

PATIENT	IMPLANT	t=0	t=3month uncovery	4.5	5.5
1.	35	0	0.5	0.5	0.5
	36	0	0.5	0.5	0.5
	37	0	0.4	0.5	0.5
2.	35	0	0.3	0.3	0.4
	36	0	0.3	0.3	0.5
3.	21	0	0.5	0.5	0.5
	23	0	0.5	0.5	0.5
4.	21	0	0.3	0.3	0.3
5.	46	0	0.2	0.3	0.3
	47	0	0.2	0.3	0.3
6.	24	0	0.5	0.5	0.5
	25	0	0.5	0.5	0.5
7.	45	0	0.2	0.3	0.3
	46	0	0.3	0.3	0.3
8.	41	0	0.8	0.8	0.8
	31	0	0.8	0.8	0.8
9.	15	0	0.5	0.6	0.6
	16	0	0.5	0.6	0.6
10	45	0	0.4	0.4	0.4
	46	0	0.4	0.4	0.4
Radiographic alveolar crest bone loss around the implants (mean ±SD)		**-**	**0.43±0.17**	**0.46±0.16**	**0.48±0.15**

Table 4 Radiographic alveolar crest bone loss around the implants (mesial/distal) in mm at defined time intervals throughout the investigation.(Vixwin pro 2000, Gendex imaging)

Paired Samples Test						
		Mean	Std Deviation	T	df	Sig. (2 Tailed)
Pair 1	RBLT0 - RBL3M	-.43000	.16890	-11.386	19	.778
Pair 2	RBL3M - RBL4.5M	-.03000	.04702	-2.854	19	.684
Pair 3	RBL4.5M - RBL5.5M	-.01500	.04894	-1.371	19	.186
Pair 4	RBL3M - RBL5.5M	-.04500	.06048	-3.327	19	.096

Table 5 Radiographic alveolar crest bone loss (RBL) around the implants (mesial/distal) in mm