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RESEARCH ARTICLE

COMPARATIVE EVALUATION OF CRESTAL BONE LOSS AROUND SUBMERGED AND NON-SUBMERGED IMPLANTS WITH DIFFERENT TYPES OF HEALING ABUTMENT DESIGNS - AN IN VIVO STUDY

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Abstract

Successful osseointegration is observed predictably for submerged implants requiring a two-stage procedure as well as for non-submerged implants characterized by one-stage surgical procedure. This study was aimed at evaluating and comparing crestal bone alterations around submerged and non-submerged implant radiographically. Total 45 patients aged between 20 to 50 years with missing mandibular posterior teeth were divided into 3 groups [Submerged implants (n=15), Non-submerged implants with anatomic healing abutment (n=15) and Non-submerged implants with esthetic healing abutment (n=15)]. Radiographic evaluation of mesial and distal marginal bone loss was done at 1 month and 3 months. Statistically significant differences were found between submerged dental implants and non-submerged dental implants with anatomical type of healing abutment designs ($P < 0.001$) and between the two non-submerged dental implant groups with different types of healing abutments ($P < 0.001$) at 1 month and 3 months. But there was no statistically significant difference between submerged dental implants and non-submerged dental implants with esthetic type of healing abutments ($P > 0.05$) at 1 month and 3 months. It was concluded from this study that bone resorption during the osseointegration period using the non-submerged technique varied significantly depending on the morphology of the healing abutment used. The non-submerged technique with an esthetic healing abutment produced an equally predictable outcome compared with the submerged technique.

Introduction:-

Dental implants have transformed the face of dentistry over the past 25 years for replacing missing teeth.[1,2] Albrektsson et al proposed that a dental implant can be considered successful if peri-implant crestal bone loss is less than 1.5 mm during the first year after implant placement and less than 0.2 mm annually thereafter.[3] The original concept of the two-stage surgical protocol described by Branemark was based on submerged healing which improved new bone formation and remodeling following implant placement.[4]

However, recent studies have demonstrated successful osseointegration using a single-stage surgical technique. Implants are not submerged during the time of osseointegration in this technique.[5] The long-term viability of this

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non-submerged technique has been shown by various studies.[6,7] Benefits of the non-submerged technique includes single surgery, more cost-effective and minimizing the changes in the coronal direction of the mucogingival junction.[8,9] However, very few studies have made a clear comparison regarding osseointegration process between submerged and non-submerged protocols. So, this in vivo study was aimed at evaluating peri-implant crestal bone loss during the osseointegration period, comparing submerged and non-submerged implants with healing abutments of different designs.

Materials And Method:-

A total of 45 patients, aged 20-50 years, with missing mandibular posterior teeth who sought implant supported prosthetic rehabilitation were selected in the Department of Prosthodontics, Government Dental college & Hospital, Ahmedabad. Ethical committee clearance was obtained. Patient's informed consent was taken and they were voluntarily permitted to be part of the study. Patients with overall good health without any major medical history, good oral hygiene, stable posterior occlusion, absence of active infection around the surgical site and absence of parafunctional habits were included in the study. Patients with uncontrolled medical conditions, chronic smokers, bone augmentation required at the time of surgery and presence of parafunctional habits were excluded from the study.

The following groups were created:

Group 1: Implant placement with submerged technique (n=15)

Group 2: Implant placement with non-submerged technique and anatomical healing abutment (n=15)

Group 3: Implant placement with non-submerged technique and esthetic healing abutment (n=15)

Dentium Superline implants (Seoul, Korea) were used for the present study. In the submerged group, 3-0 nylon monofilament sutures were used for closure. For other 2 groups, one of the two separate healing abutment macro designs was screwed into place (Dentium anatomical abutments, 4 mm in height and tapered at 120° or Dentium esthetic abutments with the same height and taper as the anatomical abutments but with a narrower base than the implant platform) (Fig 1). Alcohol free mouth rinse twice a day was advised for plaque control.

Radiographic evaluation of marginal bone levels using Rinn XCP (extension cone parallel unit, Dentsply, UK) along with lead grid was done on the day of implant placement (baseline), at 1 and 3 months. Radiographs were taken by Intraoral periapical film (Kodak E speed film) using parallel technique (Fig 2 and 3). In order to standardize the parallel procedure, patients' bites were registered with the Addition silicone Putty (Affinis Putty Super soft, Coltene, Switzerland). At various time intervals, subsequent radiographs were taken using these putty indexes.

Each radiograph was then transformed into a digital image and analyzed for distortion correction as well as magnification. Images were restored to true size in Adobe photoshop CS3 version 10.0 software and measurements for bone loss assessment were taken. The shoulder of the implant was used as a reference point for calculating bone loss.

The measurements were taken for each of the radiographs as follow:

1) Mesial bone loss: The distance between mesial edge of implant platform point and the mesial point where the implant meets the alveolar crest point in millimetres.

2) Distal bone loss: The distance between distal edge of implant platform point and the distal point where the implant meets the alveolar crest point in millimetres.

The amount of bone level present at baseline was measured and was then compared with the amount of bone loss that occurred at 1 month and 3 months.

Results:-

Mean mesial and distal bone loss around implants at 1 month and 3 months are depicted in Table 1. One-way ANOVA test was conducted to compare bone loss between 3 groups (Table 2) and post-hoc Tukey's HSD test was done for pair-wise comparison (Table 3,4,5,6).

Table 1:- Mean bone loss around implants (in mm).

Group	n	Mesial 1 month	Mesial 3 months	Distal 1 month	Distal 3 months
Submerged	15	0.052	0.108	0.051	0.110
Anatomical	15	0.260	0.365	0.260	0.366
Esthetic	15	0.029	0.150	0.027	0.150

Table 2:- One-way ANOVA comparing mesial and distal bone loss.

		Sum of squares	Mean square	F	P value
Mesial 1 month	Between groups	0.487	0.243	25.870	0.000
	Within groups	0.395	0.009		
	Total	0.882			
Mesial 3 months	Between groups	0.569	0.284	23.132	0.000
	Within groups	0.516	0.012		
	Total	1.085			
Distal 1 month	Between groups	0.493	0.246	31.135	0.000
	Within groups	0.333	0.008		
	Total	0.825			
Distal 3 months	Between groups	0.569	0.284	21.949	0.000
	Within groups	0.544	0.013		
	Total	1.113			

Table 3:- Pair-wise comparison of Mesial bone loss at 1 month.

		Mean difference	Std error	P value
Submerged	Anatomical	-0.2080000*	0.0354	0.000
	Esthetic	0.0233333	0.0354	0.788
Anatomical	Submerged	0.2080000*	0.0354	0.000
	Esthetic	0.2313333*	0.0354	0.000
Esthetic	Submerged	-0.0233333	0.0354	0.788
	Anatomical	-0.2313333*	0.0354	0.000

*. The mean difference is significant at the 0.05 level.

Table 4:- Pair-wise comparison of Mesial bone loss at 3 months.

		Mean difference	Std error	P value
Submerged	Anatomical	-0.2566667*	0.0405	0.000
	Esthetic	-0.0420000	0.0405	0.558
Anatomical	Submerged	0.2566667*	0.0405	0.000
	Esthetic	0.2146667	0.0405	0.000
Esthetic	Submerged	0.0420000	0.0405	0.558
	Anatomical	-0.2146667*	0.0405	0.000

*. The mean difference is significant at the 0.05 level.

Table 5:- Pair-wise comparison of Distal bone loss at 1 month.

		Mean difference	Std error	P value
Submerged	Anatomical	-0.2086667*	0.0325	0.000
	Esthetic	0.0246667	0.0325	0.730
Anatomical	Submerged	0.2086667*	0.0325	0.000
	Esthetic	0.2333333*	0.0325	0.000
Esthetic	Submerged	-0.0246667	0.0325	0.730
	Anatomical	-0.2333333*	0.0325	0.000

*. The mean difference is significant at the 0.05 level.

Table 6:- Pair-wise comparison of Distal bone loss at 3 months.

		Mean difference	Std error	P value
Submerged	Anatomical	-0.2560000*	0.0416	0.000
	Esthetic	-0.0400000	0.0416	0.604
Anatomical	Submerged	0.2560000*	0.0416	0.000
	Esthetic	0.2160000*	0.0416	0.000
Esthetic	Submerged	0.0400000	0.0416	0.604
	Anatomical	-0.2160000*	0.0416	0.000

*. The mean difference is significant at the 0.05 level.

Discussion:-

Original concept of the two-stage surgical procedure by Branemark (1977) was based on submerged healing. Multiple studies were conducted which resulted in wide spread acceptance of the protocol.[7] However, with changing trend and need for innovations, the non-submerged technique came to birth. Numerous studies highlighted its advantages and long-term success.[5-12]

Direct comparison of crestal bone loss on mesial and distal aspect of the submerged and non-submerged dental implants with anatomical and esthetic healing abutment design was done in this randomised controlled prospective study. Radiographic evaluation at 0, 1 and 3 months were done. Mean mesial and distal bone loss at 1 and 3 months were greater for non-submerged anatomic healing abutment group ($p < 0.000$). Mean mesial and distal bone loss at 1 and 3 months between submerged group and non-submerged esthetic healing abutment group were statistically not significant ($p > 0.05$). Radiographic bone loss at the end of 1 month in implants with esthetic abutment group were the least followed by submerged implants group. At the end of 3 months, implants with submerged technique had minimal crestal bone loss which was followed by non-submerged implant with esthetic healing abutment group.

When using non-submerged implant placement with cervically tapered abutment with platform switching and esthetic purpose, the cervical crestal bone loss was similar to submerged technique. This approach was based on the concept that a cervically tapered abutment and the consequent mismatching with the implant neck might decrease the vertical component of the biological width and create a greater horizontal distance to confine the inflammatory cell infiltrate. Accentuated level of bone resorption was observed when non-submerged implant placement with conventional anatomical abutment without platform switching was used.

Some authors have found submerged and non-submerged techniques to be equally predictable. Astrand et al compared the survival rate of both ITI and Branemark implants in a split-mouth design. No significant difference in survival rate or in marginal bone change could be demonstrated between the two systems.[7]Becktor J et al observed that a circumferential horizontal mismatch of 0.5 mm at platform of implant was able to prevent the apical downgrowth of the barrier epithelium over an observation period of 28 days.[13] While other authors claimed that there may be a higher rate of implant failure with non-submerged implant placement technique.[14]

It should also be observed that newer studies have evaluated not only implant longevity in relation to crestal bone levels around the implants, but also in relation to other factors like inflammatory response of gingiva, probing depth, primary stability, and/or patient satisfaction etc. All these factors suggest that the non-submerged implant placement technique can be as predictable as the submerged implant placement technique.[1,5,7,15]

The effect of a concave transmucosal profile on the vertical stability of soft tissues and the facial characteristic of dental implants was assessed in 2007 by Rompen et al and no recession greater than 0.5 mm was observed in either case.[16] In this sense, in 2015, in the animal model, the thickness, density and orientation of connective tissue fibers were analyzed by Delgado-Ruiz et al around healing abutments with various geometries and they concluded that abutment geometry affects the orientation of collagen fibers; thus, an abutment with a larger profile than the implant platform favours oblique and perpendicular orientation of collagen fibers and greater thickness of connective tissue.[17]

The key challenge in evaluating the present findings with other published studies is the consideration of follow-up time, as the osseointegration period (3 months) was the follow-up period of the present study, while other researchers preferred longer follow-up times, with the exception of one study by Cordaro et al that performed a randomized, multicenter, controlled, prospective clinical study of 30 patients, divided randomly into submerged and non-submerged groups. The patients received conical implants in the incisor-canine-premolar region to replace the lost teeth. Marginal bone resorption findings after 3 months were 0.26 ± 0.34 mm for the non-submerged group and 0.46 ± 0.4 mm for the submerged group, with no statistically sound variations between the groups ($p = 0.280$).These findings vary significantly from the results of the present group in the submerged group, which may be due to the location of the implant (sub- or juxta-crestal in post-extraction sockets), the type of implant used (different brands and different sizes of the polished collar) or the position in which the implant was inserted (anterior, premolar). It is difficult to compare the findings for the non-submerged group with the present results, as the authors did not provide information of the morphology of the healing abutments used. [18]

The key finding of the present analysis – which may prove to be significant – is the impact of abutment morphology on the outcome. However, as the literature contains few publications on this subject, it is difficult to make any clear comparisons with other studies. Lopez-lopez et al used an animal model that achieved better outcomes with tapered anatomical abutments (more narrow at the base than at the crown) than with parallel wall abutments.[19]

The current study used two separate healing abutments: a markedly tapered anatomical abutment and an esthetic abutment, which, in addition to its tapered appearance, often changed the platform, narrowing towards the axis of the implant.

The growth in soft tissue due to the alteration of the platform contributes to a higher defence capacity of the peri-implant complex against external noxious stimuli.[19] This could explain the better results obtained by the esthetic abutment in comparison with the anatomical abutment. The esthetic abutment's morphology could act as an additional factor in mechanical retention to orientate periodontal fibers as described by Rodrıguez et al in their study of implants with platform switching.[20]

However, considering the limitation of the analysis (small sample size, lack of anatomopathological findings that would support radiographic observation), there is a strong need for more studies into the different healing abutment macro-designs of non-submerged implants. There were few limitations in the study: Small sample size, Site specific (mandibular posteriors), Single tooth replacements and No measurement of buccal and lingual bone loss.

Conclusion:-

Bone resorption during the osseointegration period using the non-submerged technique varied significantly depending on the morphology of the healing abutment used. The non-submerged technique with an esthetic healing abutment produced an equally predictable outcome compared with the submerged technique. Peri-implant soft tissue immune response with submerged or transmucosal healing protocols demonstrated comparable outcomes during the osseointegration period.

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