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Influence of mucosal tissue thickness on placement of implant at crestal, sub-crestal and supra-crestal level: A literature review

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***Abstract*---**Introduction: Dental implants are preferred for replacing missing tooth. They form sturdy connection to bone by osseointegration. During this, bone remodelling occurs which results in bone loss. Expected normal bone loss is 0.5 mm to 1 mm. Crestal bone level is the important factor in long term implant stability and success. According to studies if mucosal tissues are thinned to <2 mm, there is significant crestal bone resorption, compared with implants placed with >2mm thickness. Linkevicious et al. performed clinical controlled study and confirmed same. Many recent studies have similar results. This literature review is framed to understand the effect of mucosal thickness on Sub-crestal, Supra-crestal and Crestal level of implant placement & its relation to amount of crestal bone loss. Aim: To evaluate how effect of mucosal tissue thickness at crestal bone level around dental implant. Methodology: Literature was selected by searching in online journals. Keywords used were “dental implants”, “vertical mucosal thickness”, “peri-implant tissues, “crestal-bone loss”,“marginal-bone loss”, “implant-abutment interface”, “biologic width”. Articles published in English Language was selected from year 1992-2019. Rationale/Hypothesis: Recent

clinical researches proved that soft tissue thickness is an important factor in preserving crestal bone around implants. It was determined that if vertical soft tissue thickness is 2 mm or less, there will be more crestal bone resorption than normal during formation of biological seal between soft tissues and implant/abutment/restoration surfaces. If the thickness is more than 2 mm then there will be less bone resorption.

***Keywords*---**Crestal bone loss, mucosal tissue thickness, dental implants, implant placement, vertical mucosal thickness, marginal bone loss.

Introduction

The successful implant placement relies on several factors, the most important of which is the marginal bone loss. Marginal bone loss in implant placement is influenced by surgical and prosthetic factors. An important additional influence on marginal bone loss is establishment of biologic width.

Albrektsson et al in 1986 established success criteria for implant treatment that included 1.5 mm loss of crestal bone in the first year of implant function. Cochran et al in 1997, discussed the influence of mucosal thickness on marginal bone loss. Further studies by Berglundh & Lindhe et al and Linkevicious et al are suggesting that minimum 2mm of vertical mucosal tissue thickness is necessary for the implant placement to minimise marginal bone loss.[1,2] This review of literature is based upon the findings of different studies based on the placement of implant system depending on vertical mucosal thickness.

In different studies it has been suggested that periodontal biotype i.e., thick (>2 mm) or thin (<2 mm) mucosal tissue, affects the dimension of the periodontal tissues after placement of implant.[2,3] A thick biotype is resilient and prone to pocket formation, while a thin biotype is friable and thus often subject to gingival recession following mechanical or surgical manipulation.

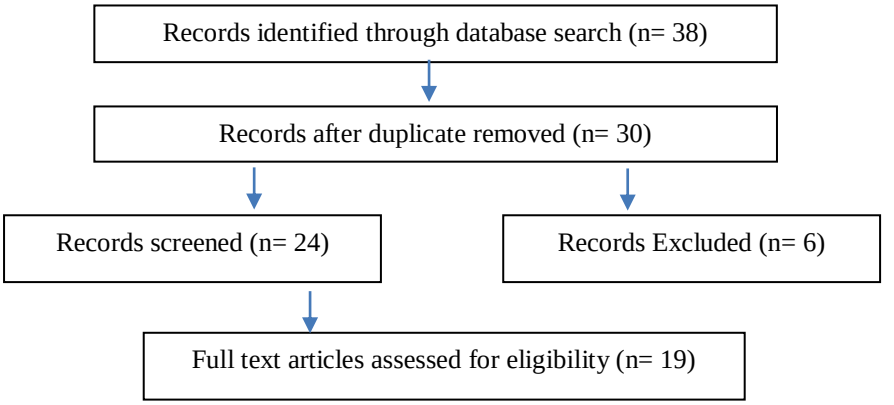
Purpose

The objective of this review is to have better understanding of the concept and evaluate the knowledge of vertical mucosal thickness and to understand future research trends intending to mucosal tissue thickness and marginal bone loss related to implant placement.

Materials and Methods

Literature was selected through a search of PubMed, Science Direct for the publications related to bone loss after implant placement. The keywords used for search were “dental implants”, “vertical mucosal thickness”, “peri-implant soft tissues, “crestal bone loss”, “marginal bone loss”, “implant abutment interface”, “biologic width”. Articles published in English Language was searched and selected from year 1992-2019.

According to the available data the articles included are Review articles, Experimental articles and Hypothetical articles. Articles were selected on the basis of evidence-based study, number of implants in a study, type of implant used for study and 1-to-2-year follow-up.



Literature Review

The experimental study of Lindhe J, Berglundh T, Ericsson I et al, in 1992, on beagle dogs. They included 5 dogs with 3 implants in each of them to study condition of peri-implant and periodontal tissues after ligature placement and along with sub gingival plaque formation. As a result, after a month of ligature removal, on clinical examination, they found that teeth and implant were intact but there was recession of gingiva and periodontal tissues and inflammation with suppuration. Amount of bone loss was evident as infiltrate in 4-5 dogs reaches to the level of crestal bone. From this study we can deduce the importance of periodontal tissues health in maintaining crestal bone level in long term. [(1)]

Joseph Y.K. Kan et al, in2003, in their clinical study, measure dimensions of peri-implant mucosa for placement of two stage maxillary anterior implant in 45 patients with average age of 47.3 years. They draw results after one year of implant placement. The dimensions of peri-implant mucosa were measured by bone sounding using periodontal probe at mesial, distal, facial and proximal aspects. As a result, greater peri-implant mucosal dimensions were noted in case of a thick peri-implant biotype as compared to thin peri-implant biotype. [(4)]

Tomas Linkevicious and Peteris Apse, in 2008, in their evidence-based review, determined and critically evaluate the present knowledge about biologic width around implants. It has been well documented in literature that bone supporting two-piece implants undergo crestal bone loss. Biologic width serves as a protective mechanism for underlying bone. By reviewing histological studies, they stated the transmigration of inflammatory cells in junctional epithelium and type I collagen found to be the dominant fibre. It has been hypothesized that a certain width of the peri-implant mucosa is required to enable a proper epithelial – connective tissue attachment and, if this soft tissue dimension is not satisfied,

bone resorption may occur to ensure the establishment of attachment with an appropriate biologic width.[5]

Tae Ju oh et al did review on causes of early implant bone loss in 2002. According to them, the success of dental implants is highly dependent on integration of implant and soft tissue. Regardless of submerged or non-submerged implant, the initial breakdown observed at crestal level. They hypothesized six etiological factors including surgical trauma, occlusal overload, peri implantitis, microgap, biologic width and implant crest module. Gingival sulcus, epithelial attachment and connective tissue attachment together constitute biologic width, average 2.04mm. this width act as a barrier against bacterial invasion and food debris ingress into implant tissue surface. They supported the study of Berglundh and Lindhe who studied the dimension of peri implant mucosa in Beagle Dog. They further stated that the epithelial attachment in both implant and natural tooth is composed of hemidesmosome and basal lamina, whereas collagen fibre direction in the connective tissue attachment is different, being parallel to implant surfaces and perpendicular to natural teeth. Studying other etiologic factors, they concluded that biologic width inevitably occurs following biomechanisms regardless of implant type, but may not be considered a sole factor associated with early implant bone loss since different levels of early implant bone loss have been reported in literature depending on implant types. [6]

Tomas Linkevicious, Peteris Apse et al, in 2009, distinguishes that what kind of mucosal tissue measured can be referred to as thin, medium or thick and its influence on crestal bone loss around dental implants. In their study, total 64 implants were evaluated in 26 patients, 14 males and 12 females, with average age of 45.6 years, ranging from 23-71 years. 32 implants as of test group were placed 2mm supra-crestally and 32 implants were positioned at crestal level. At time of implant placement mucosal tissues were divided into thin group (up to 2 mm), medium group (2.1-3.0 mm) and thick group (3.1-4.0 mm) category. Measurement of peri implant mucosa was done by raising buccal mucosal flap and thickness of unseparated palatal lingual flap was measured with 1 mm marking periodontal probe at the bone crest. At osteotomy site minimum 3 mm distance was maintained between implants and 1 mm from adjacent teeth and 1 mm from buccal and lingual/palatal crest of alveolar ridge and implant. Prosthetic procedures were initiated following 2 months of healing in the lower jaw and 4 months in the upper jaw. After one year follow up, they concluded that, crestal bone response varied in all the three groups – from 1.35 mm loss in the first group (thin), 0.32 mm in the second (medium) and 0.12 mm in the third group (thick). Implant placed at site of gingival thickness 2 mm or less, statistically significant crestal bone loss was recorded as compare to medium and thick group. The implants in the thick tissue group (3.1 mm or more) had the least bone loss on average and in some c ases even bone gain was recorded. They concluded that, the initial gingival tissue thickness can influence marginal bone level around supracrestally placed implants. Additional crestal bone loss may occur if gingival tissue at the time of implantation is up to 2 mm at the crest. If soft tissue is medium or thick, no significant bone level reduction should be expected around implants, positioned about 2 mm above bone level. It may be not rational to divide gingival tissue thickness measured at the bone crest into 3 groups – thin (up to 2.0 mm), medium (2.0-3.0 mm) and thick (3.0 mm and more),

because there was no difference between crestal bone loss around test implants, placed in medium and thick tissues. It seems that traditional division of mucosal tissues into thin and thick by the measurement of 2 mm remains the reference point. [2]

Fernando Suarez et al in 2016 in their systemic review and metanalysis on Influence of soft tissue thickness upon peri implant marginal bone loss concluded that implant placed with thicker peri implant soft tissue have less radio graphic marginal bone loss in long term. Results from the current meta-analysis confirmed previous observations demonstrating that a minimum of ≥2mm of soft tissue thickness are required for the establishment of the BW, and that in the presence of thin tissue. They further stated that, 2 mm or taller prosthetic abutment height supposed the cut-off point in the preservation of the MBL around internal conical connection implants. This review demonstrated that the peri-implant tissue thickness plays a more important role in minimizing marginal bone loss when implants are placed supracrestally rather than at the level of the crest. Crestal bone level approximated to the microgap to the bone, and thus marginal bone loss would occur due to possible bacterial leakage, therefore the marginal bone loss was significantly higher in crestal implant placement than supracrestal implant placement. Hence, soft tissue thickness evaluation at time of implant placement is strongly encouraged for clinicians and researchers. [7]

In a randomized control trial study by Rafael Amorim Cavalcanti de Siqueira et al, in 2007, there was no statistically significant bone changes between subcrestal and equicrestal positioning of implants were found. In their split mouth study, 28 equicrestal and 27 subcrestal implants were placed in eleven edentulous patients. Crestal bone changes were evaluated by taking intraoral radiographs. Subcrestal positioning resulted in crestal bone loss of 0.88mm when compared to equicrestal positioning having 0.99mm bone loss. [8]

Paul van Eekeren Pieter van Elsas Ali Tahmaseb Daniel Wismeijer, in 2016, in their prospective randomized clinical trial evaluated the crestal bone changes around bone level and tissue level implants related to initial mucosal thickness. They made 4 groups with placement of implant at crestal and supra crestal level with tissue thickness of less than or equal to 2 mm and tissue thickness more than 2 mm. Results showed statistically significant difference in crestal bone changes after one year of loading with initial mucosal thickness was implants, but no statistically significant changes if initial mucosal thickness was <2mm in tissue level implant. Conclusion is, if the initial mucosal thickness surrounding bone-level implants is more than 2 mm, there is statistically significantly less crestal bone change when compared to bone-level implants placed in initial mucosal thicknesses of 2 mm or less.[9]

Paul J.A. van Eekeren, Ali Tahmaseb, Daniel Wismeijer, in 2016, in their systemic review and meta-analysis evaluate crestal bone changes around implants when placing the implant-abutment connection at the crestal bone level or above. Physiologic remodelling starts to ensure healing of bone, in which bone reaches the rough surface of implant, locking the implant in its site. Shape of crestal bone changes both horizontally and vertically. They also stated that the markable bone loss was noted in tissues with mucosal thickness less than 2 mm.[10]

Tomas Albrektsson, Daniel Buser, Lars Sennerby, in 2012, in their report of consensus meeting to analyse critically whether the high figures of peri-implantitis at machined implants that recently have been reported in the literature are valid also for modern implants. After evaluating different studies, they concluded that bleeding on probing is the indicator of crestal bone loss. Crestal bone loss may occur due to many other reasons than infection. Inflammation is the fundamental mechanism that initiates and propagates bone resorption. In the literature quite neglected, reason for marginal bone loss is the foreign body reaction that may remain totally aseptic but still cause crestal bone loss due to an inflammatory response. One practical example is the presence of excess cement at the submucosal crown margins. (11)

Silvio Mario Meloni, Edorado Baldoni, Milena Pisano, Antonio Tullio, Giacomo De Riu, Marco Tallarico, in 2018, in their split mouth randomized control pilot trial study to evaluate hypothesis that implants inserted at bone level or supracrestally have different outcomes in single tooth replacement. Their study was designed as a randomized control pilot trial, a split mouth study with ten patients treated with 20 implants featuring 0.75 mm of machined collar implants. One implant placed at 0.75 mm below crestal bone level and 1 mm above crestal bone level. Measurements were done with periodontal probe. Marginal bone levels were evaluated by parallel technique for radiography. Distances were measured from mesial and distal interproximal bone to the horizontal interface between the implant and abutment. They recorded results after one year follow up of patients, the mean marginal bone loss in implants placed 1 mm above the alveolar crest was 0.28 mm and in the group in which implants were placed 0.75 mm below crest level was 0.93 mm. They recorded results after one year follow up of patients, the mean marginal bone loss in implants placed 1 mm above the alveolar crest was 0.28 mm and in the group in which implants were placed 0.75 mm below crest level was 0.93 mm. (12)

Joachim S. Hermann, David L. Cochran, Pirkka V. Nummikoski and Daniel Buser, in 1997, in their experimental animal study, tried to figure out crestal bone changes around titanium implants by evaluating difference on radiograph in submerged and non-submerged unloaded implants. Radiographic assessment was carried out by measuring the distance between the top of the implant/abutment and the most coronal bone -to-implant contact. Reason for crestal bone loss was bacterial colonization of the microgap and implant components. The epithelium could attach to the stable implant rather than to the abutment. Under these circumstances, a biologic width could form apical to the microgap and account for the 2 mm distance between the microgap and alveolar bone.(13)

Tomas Linkevicius, Dip Pros, Algirdas Puisys, Marius Steigmann, Egle Vindasiute, Laura Linkeviciene, in 2015, in their comparative clinical study evaluate crestal bone level around platform switched implants placed in thick and thin mucosa. They made two groups, first group was of thin mucosal tissue 2 mm. periodontal probe was used to measure mucosal tissue thickness. Radiographic examination was performed after implant placement, 2 months after healing, after restoration, and at 1-year follow-up postreconstruction. Crestal bone loss was calculated. Mean soft tissue thickness in Group 1 was 1.53 mm and soft tissue thickness in

Group 2 was 2.98 mm. In thin tissue group 0.71 mm mean bone loss recorded and 0.21 mm bone loss in thick tissue group. They concluded that, vertical soft tissue thickness plays a major part in the etiology of early crestal bone loss.[3]

Georgios E. Romanos, Erhan Aydin, Kathrin Gaertner, Georg-Hubertus Nentwig, in 2013, in their experimental study found out that prevention of peri-implant bone loss is essential for achieving long-term implant success. They placed 228 delayed implants in 85 patients. Patients were divided retrospectively into two groups based on the implant shoulder position on the day of placement surgery as follows: sub-crestal group or crestal group. Mesial and distal bone loss was evaluated under 5X magnification and analyzed, along with Periotest values. For sub-crestal group, mean mesial bone loss was 1.84 mm and mean distal bone loss was 1.73 mm. For crestal group, the bone loss values were, for mesial 1.41 mm and distal 1.34 mm. They further stated that in the present study, the values found for marginal bone loss around implants placed both crestally and sub-crestally were comparable and similar with those reported previously in the literatur e. Implant placement at the bone level may be associated with a higher risk of implant exposure. Placing the implant sub - crestally minimizes that risk, and sub-crestal placement of platform-switched implants enables bone stability or growth over the implant shoulder.[14]

Algirdas Puisys and Tomas Linkevicious, in 2014, in their prospective controlled clinical trial evaluate how bone-level implants maintain crestal bone stability after thickening of thin mucosal tissues with allogenic membrane. 97 patients were included in their study. According to vertical gingival thickness, patients were assigned into 3 groups. One group of thin mucosal thickness, 2 mm. After two months they evaluated groups for the results. Implants with thin mucosa was found to have mean bone loss of 0.75 mm mesially and 0.73 mm distally, in second group, with thin mucosa which made thick by alloplastic membrane use, 0.16 mm mesially and 0.20 mm distally, in third group, with naturally thick mucosal membrane, 0.17 mm mesially and 0.18 mm distally. Results have confirmed that initial mucosal tissue thickness might be a major factor in crestal bone loss etiology. Implants in control group with naturally thick soft tissues had the least bone loss, although not significantly less than implants in second with thickened soft tissues. It can be concluded that both soft tissue types – naturally thick and thin, thickened with allogenic membrane do not differ in capability to maintain crestal bone stability.[15]

Vervaeke et al, in 2014, in their study find the effect of initial soft tissue thickness on peri-implant bone remodeling. Their research hypothesis was that implants installed in patients or at sites with thin mucosal tissues would show increased peri-implant bone loss. They took 75 edentulous patients for their study and during recall visits peri-implant health was determined by means of probing depth, bleeding index, digital periapical radiographs and bone level changes were measured from a reference point (lower border of the smooth implant collar) to the marginal bone -to implant contact level. Mean bone level changes were 0.89 mm and 0.90 mm after 1 year and 2 years respectively. This study proves that early bone remodeling is affected by the initial soft tissue thickness at the time of implant placement. [16]

Michael Fetner et al in 2015, in their histologic study in dogs, aim to determine the crestal bone changes around implants placed at different depths. 36 two-piece implants were placed bilaterally in dogs. 3 implants were placed randomly at the bone crest, 1.5 mm subcrestally or 3.0 mm subcrestally. Abutments were placed after 3 months and at 6 months micro-CT and histologic evaluations were done. In their results, subcrestal implants loss less crestal and marginal bone than the equicrestal implants. Hence they concluded that subcrestal placement of implant appears to be advantageous in maintaining bone height. [17]

Vervaeke et al in 2018, in their prospective study evaluate the effect of soft tissue thickness on remodelling of bone after implant placement and to investigate if implant surface exposure can be avoided by adapting the vertical implant position in relation to the soft tissue thickness. Soft tissue thickness was measured using ultrasonic device, which is a non-invasive method. One implant was installed equicrestally (control) and the vertical position of the second implant was adapted to the site -specific soft tissue thickness (test). A significant correlation was observed between soft tissue thickness and bone level alterations after 6 months, in 25 patients. Mean initial soft tissue thickness of 1.93 mm and 1.98 mm was measured before implant placement, using bone sounding and ultrasonic measurements, respectively. After 6-, 12- and 24-months control implants (equicrestal implants) showed a mean bone level of 0.72 mm, 0.78 mm and 0.73 mm respectively, compared with a mean bone level of 0.04 mm, 0.03 mm and 0.04 mm for the test implants. Sub-crestal implants showed significantly better bone levels after 6 months. Based on results they concluded that initial bone remodeling was affected by soft tissue thickness. Bone levels remained unaffected for next 2 years. Implants placed with thin mucosal thickness, 2mm. Anticipating biologic width re -establishment by adapting the vertical position of the implant, seemed highly successful to avoid implant surface exposure. [18]

Esposito in 2019, in their split mouth study, evaluate the placement of single dental implants either 0.5 mm or 1.5 mm sub-crestally in healed bone crests to study long term effects. Sixty partially edentulous patients requiring two single implant- supported crowns were included in there study. According to a split-mouth design, the two sites were randomly allocated either to 0.5 mm or 1.5 mm sub-crestal implant placement. One of the outcome measures was peri-implant marginal bone changes. A slightly lower bone resorption was measured with 1.5 mm sub-crestal placement compared to 0.5 mm, with no impact on the esthetic score. [19]

Author & year	Title	Methods	Result
Lindhe J, Berglundh T, Ericsson I, Liljenberg B, Marinello C, 1992[1]	Experimental breakdown of peri-implant and periodontal tissues. A study in the beagle dog	5 beagle dogs were included in experiment. 3 fixtures installed and radiographic examination at end of 6th month. After a month of	Clinical and radiographic signs of tissue destruction. At implant site soft tissue lesion was larger.

		ligature removal, again radiographic examination done	
Cochran DL, Hermann JS, Schenk RK, Higginbottom FL, Buser D., 1997[13]	Biologic Width Around Titanium Implants. A Histometric Analysis of the Implanto-Gingival Junction Around Unloaded and Loaded Nonsubmerged Implants in the Canine Mandible	6 dogs were incorporated in study. 69 titanium plasma sprayed and sand blasted acid etched implants were placed. Animals scarificed after 3 and 12 months of implant loading. Examination include sulcus depth, junctional epithelium & connective tissue contact.	After 3 months: Mean value of sulcus depth= 0.49mm Dimension of junctional epithelium= 1.16mm Connective tissue contact= 1.36mm After 12 months: Sulcus depth=0.16mm Junctional epithelium= 1.88mm Connective tissue contact= 1.05mm
Kan JYK, Rungcharassaeng K, Umezu K, Kois JC, 2003[4]	Dimensions of Peri-Implant Mucosa: An Evaluation of Maxillary Anterior Single Implants in Humans	45 maxillary implants were evaluated in 32.5 months mean time. Dimensions of peri-implant mucosa were evaluated by periodontal probe on all sides.	Dimensions: Mesio proximal= 4.20 +/- 0.77mm Disto proximal= 4.20 +/- 0.64 mm Mesial= 6.17 +/- 1.27mm Distal= 5.93 +/- 1.21 mm Mid facial= 3.63 +/- 0.91mm
Linkevicius T, Apse P, 2008[5]	Biologic Width Around Implants. An Evidence-Based Review	The literature was selected through several electronic databases, as well as a manual search in the major dental	Evidence analysis shows that the present knowledge about biologic width around implants is mainly derived from animal studies and that clinical controlled human studies are insufficient.

		implant, prosthetic and periodontal journals. The reviewed data was published in English from 1980 to December 2007	
Oh TJ, Yoon J, Misch CE, Wang HL, 2002[6]	The Causes of Early Implant Bone Loss: Myth or Science?	Review	Early implant bone loss during healing and first year of function is greater than subsequent years. Early bone may be due to trauma, occlusal overload, inflammation, biologic width.
Linkevicius T, Apse P, Grybauskas S, Puisys A, 2009[2]	Reaction of crestal bone around implants depending on mucosal tissue thickness. A 1-year prospective clinical study.	Totally 64 implants were evaluated in 26 patients. 32 implants (test group) were placed about 2 mm supracrestally and 32 implants (control group) were positioned equal to the bone level. Mucosal tissues at a time of implant placement were divided into 3 groups - thin, medium and thick. Crestal bone changes were measured at implant placement and after a 1- year follow-up.	Mean bone loss in thin tissue group was 1.35 mm+/- 0.33mm. Mean bone loss in medium thickness group was 0.32 mm +/- 0.44mm Mean bone loss in thick tissue group was 0.12mm +/- 0.16 mm.
Suárez-López del	Influence of Soft	An electronic	Eight articles were included

Amo F, Lin GH, Monje A, Galindo-Moreno P, Wang HL, 2016[7]	Tissue Thickness on Peri-Implant Marginal Bone Loss: A Systematic Review and Meta-Analysis	and manual literature searches were performed by two independent reviewers (FSLA and AM) in several databases, including MEDLINE, EMBASE, and Cochrane Oral Health Group Trials Register databases for articles up to May 2015 reporting soft tissue thickness at time of implant placement and MBL with at least 12-month follow up	in the systematic review and five were also included in the quantitative synthesis and meta-analyzed to examine the influence of tissue thickness upon early marginal bone loss (MBL). Metaanalysis for the comparison of MBL among selected studies showed a weighted mean difference of -0.80 mm, with a 95% CI= -1.18 mm to -0.42 mm (p< 0.0001), favoring the thick tissue group.
de Siqueira RAC, Fontão FNGK, Sartori IA de M, Santos PGF, Bernardes SR, Tiossi R, 2017[8]	Effect of different implant placement depths on crestal bone levels and soft tissue behavior: a randomized clinical trial	Eleven edentulous patients were randomly divided in a split-mouth design: 28 equicrestal implants (G1) and 27 subcrestal (1-3mm) implants (G2). Standardized intraoral radiographs were used to evaluate crestal bone (CB) changes. Patients were	Fifty-five implants (G1 = 28 and G2 = 27) were assessed. Implant and prosthetic survival rate were 100%. Subcrestal positioning resulted in less crestal bone (CB) loss (-0.80mm) when compared to equicrestal position (-0.99 mm), although the difference was not statistically significant (P > 0.05). Significant CB loss was found within the G1 and G2 groups at two different measurement times (T4 and T60) (P < 0.05). Implant placement depths and vertical mucosal thickness had no effect on soft tissue recession (P > 0.05).

		assessed immediately, 4-, 8-, and 60-months after implant placement. The correlation between vertical mucosal thickness (VMT) and soft tissue recession was analyzed	
van Eekeren P, van Elsas P, Tahmaseb A, Wismeijer D, 2017[9]	The influence of initial mucosal thickness on crestal bone change in similar macrogeometrical implants: a prospective randomized clinical trial	Patients received at least 2 implants: one with the prosthetic abutment connection at the crestal bone level (MC) and one with the prosthetic abutment connection at 2.5 mm supra crestal (LC). Flap thickness measurements were taken using a periodontal probe after raising the buccal flap. Patients were divided into 2 groups according to the mucosal thickness—Group A (thickness, ≤2 mm) and Group B (thickness, >2	Group A (MC), 17 implants, with a mean bone change of 0.6 0.5 mm; Group B (MC), 20 with a mean bone change of 0.2 0.4 mm; Group A (LC), 15 with a mean bone change of 0.1 0.5 mm; and Group B (LC), 22 with a mean bone change of 0.2 0.4 mm. A pairedsamples t-test for groups A (MC) and B (MC) yielded a statistically significant difference (P = 0.003); there was no statistically significant difference for groups A (LC) and B (LC) (P = 0.518)

		mm)	
Albrektsson T, Buser D, Sennerby L, 2012[11]	Crestal Bone Loss and Oral Implants	Ten different studies of three modern implant brands of moderately rough surfaces with 10-year or longer follow-up times were found through a PubMed and manual search.	Bleeding on probing or probing depths are weak indicators of crestal bone loss (CBL); that CBL occurs for many other reasons than infection; that implant-, clinician-, and patient-related factors contribute to CBL; and that modern oral implants outperform older devices. Based on a literature search, the frequency of implants with reported peri-implant infection and significant bone loss leading to implant removal or other surgical intervention was on average 2.7% during 7 to 16 years of function
Meloni SM, Baldoni E, Pisano M, Tullio A, Riu GD, Tallarico M, 2018[12]	1-year results from a split-mouth randomised controlled pilot trial comparing implants with 0.75 mm of machined collar placed at bone level or supracrestally	10 patients each missing 2 bicuspids or molars. 20 implants were placed. One implant placed at bone level and other at 0.75-1 mm supra-crestally. Clinical data were collected after 1 year for marginal bone loss, bleeding on probing and pocket depth.	Mean bone loss in supra-crestal group was 0.28 +/- 0.21 mm Mean bone loss at epi-crestal group was 0.93+/- 0.37 mm.
Linkevicius T, Puisys A, Steigmann M, Vindasiute E, Linkeviciene L, 2014[3]	Influence of Vertical Soft Tissue Thickness on Crestal Bone Changes Around Implants with Platform Switching: A Comparative	80 patients received 80 bone level implants. Mucosal thickness was measured and griups divided into thin	Implants in Group 1 (thin tissue) showed 0.79 mm of bone loss after 2 months. After 1-year follow-up, bone loss was 1.17 mm. Implants in Group 2 (thick tissue) showed bone loss of 0.17 mm after 2 months of implant placement and 0.21

	Clinical Study	tissue (<2mm) and thick tissue (>2mm) mucosal thickness. Evaluation after 2 months and one year follow-up	mm after 1-year follow-up
Romanos GE, Aydin E, Gaertner K, Nentwig GH, 2013[14]	Long-Term Results after Subcrestal or Crestal Placement of Delayed Loaded Implants	228 delayed implants placed in 85 patients into two groups based on the implant shoulder position on the day of placement surgery as follows: subcrestal group A (n = 197; 0.5 mm or more below the crestal bone level) or crestal group B (n = 65; within 0.5 mm or less of the crestal bone level)	Mean Periotest values were -1.77 (13.57) for Group A and -1.77 (13.26) for Group B. For Group A, mean mesial (m) bone loss was 1.84 (11.49 mm) and mean distal (d) bone loss was 1.73 (11.31 mm). For Group B, the bone loss values were m: 1.41 (11.65 mm) and d: 1.34 (11.60 mm).
Vervaeke S, Dierens M, Besseler J, De Bruyn H, 2012[16]	The Influence of Initial Soft Tissue Thickness on Peri-Implant Bone Remodeling	79 edentulous patients were included. Periodontal health was determined by measuring pocket depth and bleeding index. Bone level changes were measured from a reference point (lower border of the smooth	Mean bone level changes were 0.89 mm (SD 0.62) and 0.90 mm (SD 0.66), plaque scores 0.82 (SD 0.94) and 0.87 (SD 0.92), bleeding scores 0.46 (SD 0.68) and 0.56 (SD 0.72) and PPD 1.65 mm (SD 0.60) and 1.78 mm (SD 0.59) after 1 year and 2 years respectively

		implant collar) to the marginal bone-to implant contact level.	
Fetner M, Fetner A, Koutouzis T, Clozza E, Tovar N, Sarendranath, 2015[17]	The Effects of Subcrestal Implant Placement on Crestal Bone Levels and Bone-to-Abutment Contact: A Microcomputed Tomographic and Histologic Study in Dogs	36 two piece dental implants were placed in six mongrel dogs in 3 groups, epicrestal placement and 1.5 mm and 3.0 mm subcrestally. After six months samples evaluated for micro-CT.	Subcrestal placement of implant leads to less bone loss as compare to epicrestal level implants.
Vervaeke S, Matthys C, Nassar R, Christiaens V, Cosyn J, De Bruyn H, 2018[18]	Adapting the vertical position of implants with a conical connection in relation to soft tissue thickness prevents early implant surface exposure: A 2-year prospective intra-subject comparison	25 patients received two implant supported over denture. One implant was placed equicrestally (control) and second implant was adapted to the site -specific soft tissue thickness(test). Crestal bone levels were determined on radiographs and compared with baseline (implant placement).	A significant correlation was observed between soft tissue thickness and bone level alterations after 6 months. Subcrestal implants showed significantly better bone levels after 6 months
Esposito M, 2019[19]	Impact of 0.5 mm vs 1.5 mm subcrestal implant placement on marginal bone	60 partially edentulous patients with 2 implant each. According to a split- mouth	A slightly lower bone resorption was measured with 1.5 mm subcrestal placement compared to 0.5 mm, with no impact on the esthetic score. This tends to

	loss and aesthetics - 3-year results of a multicenter RCT	design , the two sites were randomly allocated either to 0.5 mm or 1.5 mm subcrestal implant placement. 3 year follow-up done.	show that deeper implant placement might be beneficial only regarding bone stability, which will be confirmed after 5 years of follow- up.
Paul JA Van Eekeren, 2016[10]	Crestal bone changes around implant with Implant-Abutment connections at epicrestal level or above: Systematic review and Metaanalysis	Pubmed, EMBASE and Cochrane library upto January 2014 were searched for publication that evaluate radiographic crestal bone changes around nonsubmerged rough surface implants for 1 year.	Dental implants at bone level shows less bone loss as compare to implants placed at tissue level.

Discussion

The short and long-term studies suggested that implant placement level either crestal, sub-crestal or supra crestal, affect the crestal bone but rehabilitation with implant supported fixed prosthesis depend upon the thickness of overlying mucosa.[2,3] On reviewing the available literature, majority of studies have shown similar results, that is, if the thickness of mucosa, at time of implant placement is <2mm, then there is more crestal bone resorption and if the thickness of mucosa is >2mm then crestal bone loss is less.[2] Although the placement of sub-crestal implants was suggested to minimize bone resorption, this could be due to addition soft tissue thickness as the implant is placed at the depth. The vertical position of the implant-abutment interface, although of extreme importance, does not seem to be the only cause of bone loss, and other factors such as platform switching, types of connection, timing of abutment placement and height, and soft tissues characteristics should all be taken in account.[6] Compared to non-mismatched implant-abutment connection, internal tapered implants with platform-switching are expected to have lower bone loss due to a reduced microgap at the implant–abutment interface leading to less bacterial leakage and lower stress in the surrounding bone with non-mismatched connections are not recommended to be placed sub-crestally.[11]

Marginal bone recession was not significantly seen in the short duration , but was significantly increased in long term follow-up period.[3,12,18] In the last few years, researchers are consistently working to focus more light over the causes responsible for the loss of bone occurring when an implant is placed, especially after the first few months following the placement.

Authors [19] have stated that placing of implants sub crestally at different levels are also showing significant difference in rate of bone loss, that is, placing implant 1.5 mm deep sub crestally shows less bone loss as compare to placement of implant 0.5mm sub crestally. Similarly [19], dental implants placed at crestal level show less bone loss as compare to tissue level implant. On the other hand, acc.to Albrektsson and colleagues, in 1986[14] ,placing an implant at crestal level can be considered with higher risk of bone loss or implant exposure in considering 0.1 - 0.2 mm bone loss in a year. The formation of biological width around implants could influence the bone remodeling and this fact might explain why the resorption is more pronounced during the first year, as reported by most of the articles included in this review.[5,16]

The early bone remodeling or crestal bone loss is also influenced by the initial soft tissue thickness at the time of implant placement. The soft tissue thickness can be measured by using periodontal probe at time of placing the incision for placement of implant. The reference point of 2 mm to describe thin and thick mucosal thickness remains a rational.[2] The soft tissue mucosal thickness is necessary to establish proper epithelial-connective tissue attachment to facilitate in restoration of vascularity and to reduce the amount of bone loss which ultimately influence the success of the implant surgery and if the mucosa is thin , the bone resorption may occur for establishment of attachment with appropriate biologic width.[5]

Conclusion

From some of the existing literature, we can conclude that minimum of 2 mm mucosal thickness is necessary to prevent marginal bone loss. But this can't be fully relayed upon as some authors state that mucosal tissue thickness is not only the sole factor responsible for crestal bone loss, where other factors such as occlusal trauma, periodontal infection, patient related factors etc can also contribute. So, with the evaluation of this concept every year, long term studies has to be carried out keeping mucosal thickness as the major factor, so as to understand the effect of mucosal thickness on implant placement in long term.

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