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AUTHORS: Büsra YILMAZ,Mustafa TUNALI

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Review

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The effect of different mucosal thickness on implant crestal bone loss

Farklı mukozal kalınlıkların implant çevresi krestal kemik kaybına etkisi

Busra Yilmaz[1], Mustafa Tunali[2]

[1]Dept. of Periodontology, Ege University, Izmir, Turkey, [2]Dept. of Periodontology, Canakkale Onsekiz Mart University, Canakkale, Turkey

Abstract

A dental implant is a treatment option that is widely used nowadays and provides to giving the aesthetic, function, and phonation back to the patient in dental deficiencies. Nevertheless, the inefficacies of dental implants also draw attention for various reasons. Factors causing early period implant inefficacies are being analyzed and reasons that may be affecting marginal bone loss are being elaborated. In the literature, factors causing marginal bone loss such as premature prosthetic loading, neglected cement residues at the prosthesis stage, micro-gap foundation, infection foundation on the surgery region and traumatic surgery draws attention. One of these reasons is the thickness of the mucosa covering the region that the implant is placed (phenotype). The purpose of our review is to discuss the effect of mucosal thickness in the surgical area on the marginal bone loss in the implant area, within the scope of the literature.

Key words: *soft tissue thickness, marginal bone loss, crestal bone loss, dental implants*

Öz

Dental implantlar günümüzde sıklıkla kullanılan ve diş eksikliklerinde hastaların estetik, fonksiyon ve fonasyonunun iadesini sağlayan tedavi seçenekleridir. Buna rağmen, çeşitli nedenlere bağlı olarak, dental implantların başarısızlıkları da dikkati çekmektedir. Erken dönem implant başarısızlıklarına sebep olan faktörler araştırılmakta ve marjinal kemik kaybına etkisi olabilecek olan nedenlerin üzerinde durulmaktadır. Literatürde implant çevresi marjinal kemik kaybıyla ilgili araştırılan faktörler arasında prematür protetik yükleme, protez aşamasında göz ardı edilen siman artıkları, mikro aralık oluşumu, cerrahi sahada enfeksiyon oluşumu ve travmatik cerrahi gibi sebepler göze çarpmaktadır. Bu nedenlerden biri de implant yerleştirilecek sahayı örten mukozanın kalınlığıdır (fenotipi). Derlememizin amacı cerrahi yapılacak bölgedeki mukozal kalınlığın implant çevresi marjinal kemik kaybı üzerine etkisini güncel literatür desteğinde tartışmaktır.

Anahtar kelimeler: *yumuşak doku kalınlığı, marjinal kemik kaybı, krestal kemik kaybı, diş implantları*

Corresponding author: Busra Yilmaz, Ege Üniversitesi Diş Hekimliği Fakültesi Periodontoloji ABD, Erzene M, Ankara C. Bornova, Izmir,Turkey, Phone: +90 232 388 03 25, E-mail: busra1.yilmaz@ege.edu.tr

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Introduction

Dental implants are widely used nowadays, and they are known as the gold standard treatments for dental deficiencies. Despite this extensive application area, it is important for dental implants to maintain their functional and aesthetic achievement in the long run. Risk factors causing implant failures are topics that are still being researched.[1]

Maintenance of the alveolar bone health, and especially the prevention of bone loss on the implant's neck area is the primary problem and research subject in the achievement of dental implants. In 1994, Alberktsson and Isidor[2] claimed that after 1 year from a successful dental implant loading, bone loss up to 1.5 mm on the marginal bone is clinically acceptable. Nowadays, this 1.5 mm bone loss is not acceptable for reasons of factors such as patient's growing aesthetic expectations, increasing average life, and it is tried to be prevented.[3] Various studies have been held to prevent marginal bone loss, such as the influence of the micro-gap between the implant-abutment, using platform-switch implant-abutment, the dental implant being positioned differently according to the alveolar crestal, modified surface usage on the neck area of the implant, impacts of different implant designs, decreasing the surgical trauma, effects of abnormal prosthetic loading. As a new viewpoint, soft tissue structure on the region where the implant will be placed and its quality's effect on the marginal bone loss have been started to be evaluated in scientific researches.

The purpose of our study is to make an updated literature review of the studies about the effect of mucosal thickness in individuals who have different mucosal thicknesses on the crestal bone loss.

Periodontal and peri-implanter mucosa

The soft tissue around the dental implant is named peri-implanter mucosa. The post-implant-surgery wound healing process determines the characteristics of peri-implanter mucosa. Soft tissue attachment occurs when the mucosa heals. This is called transmucosal attachment. Transmucosal attachment protects the bone from inside the oral cavity during osseointegration and rigid fixation.[4]

Supracrestal soft tissue attachment (biologic width)

The width of the tooth-facing of soft tissue is defined as biologic width of soft tissue. Gargulio et al. defined the connective tissue attachment, gingival crevicular and connection epithelium in a study they have done in 1961. As a result of the histometric measurements, they have determined that the connection epithelium right under the 1.07 mm connective tissue attachment and gingival crevicular is 0.97 mm on average. It is said that the total of 2.04 mm of these two values is the mean value of biologic width. Today, this area is called supacrestal soft tissue attachment.[5] Supracrestal soft tissue attachment occurs around implants like natural teeth. In the peri-implant region, it consists of a marginal epithelium surrounding the implant surface, called the epithelial attachment, and a connective tissue attachment consisting of collagen fibers adhering to the implant surface.[6] To avoid bacterial penetration and protect peri-implant structures, this soft tissue barrier, supracrestal soft tissue attachment, must be formed.[7] Various factors determine the amount of biological width in periimplant tissues, such as the surface properties of the implant, their design, and loading protocols. The amount of crestal bone loss that occurs during the development of the biological width is determined by these variables, which are typically related to the quality of the mucosal seal.[6]

The structure of the peri-implanter soft tissue has been studied in various human and animal researches. In a study conducted on dogs by Berglundh et al. in 1991, characteristics of the gingiva around the teeth and anatomical characteristics of the mucosa around the implant are compared. It is seen that the color of clinically healthy gingiva and peri-implanter mucosa is dusty rose pink. When radiographs are examined, it was determined that alveolar bone level on the dentated area is on the 1 mm apical of cement-dentin con-

nection. It was determined that marginal bone crestal is close to implant-abutment connection.[4,8]

Histological studies have shown that peri-implanter and periodontal soft tissues have common characteristics. The gingival epithelium is finely keratinized and continues with a thin connection epithelium on the surface facing the dentin, ends on the dentin-cement connection. Supraalveoler connective tissue is at a level of approximately 1 mm, and the width of the periodontal ligament is 0.2-0.3 mm. External of the peri-implanter mucosa is covered with a keratinized epithelium continuing with a thin barrier epithelium on the marginal side. This barrier epithelium has a thickness of several cell layers and ends at the 2 mm apical of the soft tissue margin. The titanium oxide surface of the implant is in direct contact with the connective tissue on the bone. This connective tissue contains collagen fibers. Collagen fibers are rooted from the periost of alveolar bone crestal and go parallelly towards the abutment surface of the soft tissue margin. Periodontal epithelium and peri-implanter epithelium take root on the dens/implant surface with hemidesmosomes.[4]

In a healthy mucosa, the barrier epithelium should be in a coronal position of 1-1.5 mm from the level of the alveolar bone. Connective tissue-based fibroblasts of the mucosa generate a connection to the titanium oxide surface in the apical of abutment part in the post-implant-surgery recovery period.[4]

Even though Abrahamson et al. used different types of implants in the studies they held on dogs in 1996 and 2002, they have shown that similar mucosal attachments will form. Also, it was shown that attachment formation is an independent process from whether the implant is submerged or not.[9,10]

Epithelium and connective tissue components around the transmucosal attachment of implant are important for wound healing. This wound healing happening after the implant has been placed, is a sore process including a several-week tissue remodeling. In other words, the formation of the transmucosal attachment is essential in wound healing success in the post-surgery process.[4]

Peri-implanter soft tissue quality

In a study conducted by Berglundh et al. in 1991, dens and connection tissues around the implant had been examined. They said that the most important difference in the mesenchymal tissues around the dens and implant is the cement formation around the root. Cement-based thick dentoalveolar and dentogingival fiber bundles around the natural teeth come in lateral, coronal and apical directions. Processes of the collagen fibers around the implant; however, are totally different. Collagen fibers rooted from the periosteum of bone crestal go parallelly towards the implant surface. And some of the fibers are seen as bundles on the far areas from the implant surface.[4,8]

There are more collagen fibre substances in the connective tissue around the implant than natural teeth. Again, they contain less fibroblast and vascular element. Moon et al. determined in a study conducted in 1999 that there are only a couple of blood vessels around the implant. Various fibroblasts have been found throughout the implant's long centerline. It was seen that when the lateral components of the implant increase, fibroblast number decreases and collagen fibre and vascular structure increases. Studies similar to Moon et al.'s study have found the same results and it was concluded that the connective tissue around the implant is fibroblast rooted.[4,11]

Gingiva blood build-up in teeth occurs from two main sources. One of them is supraperiosteal blood vessels, and the other one is periodontal ligament-based vascular plexus. Blood build-up in the peri-implanter tissues has been examined on dogs by Berglundh et al. in 1991. The main source of blood build is shown as the supraperiosteal blood vessels on the bone. These vessels vein in the supraalveolar mucosa, form capillary vessels under the oral epithelium, and vascular plexus in the lateral of barrier epithelium. The connective tissue of the transmucosal attachment contains only a couple of blood vessels. All of these vessels can be named as the terminal veins of the supraperiosteal blood vessels. In other words, they show differences in the blood build-up point although periodontal soft tis-

sues share various characteristic features.[4] Despite the fact that osseointegrated implants can be successfully maintained over time, the presence of periimplant mucosal recessions can have a significant impact on esthetic outcomes, patient satisfaction, as well as biological and clinical stability, all of which are important factors for a long-term good prognosis.[12] The inability of soft tissue around the implant compromises esthetics, especially in the interproximal papillary and facial aspects. In addition, in cases where the soft tissue is improved by grafting methods, it has been reported that periimplanter clinical parameters such as bleeding on probing and probing depth are better.[13] Anatomic and prosthetic aspects both play a role in the successful modeling of soft tissues. To ensure soft tissue responsiveness to prosthetic stimuli, an adequate blood supply must first be provided, followed by an appropriately linked and positioned abutment, which serves as the foundation for a well-designed interim prosthetic component.[14] At this point, it seems that ensuring the correct organization of the soft tissue around the implant is very critical for maintenance of dental implants.

Soft tissue grafts and membranes

Soft tissue grafts have been used for many years in the reconstruction of crest defects and in gingival recession.[15] Also, soft tissue thickness was increased in some studies where autogenous and allogenic grafts were used to prevent early period marginal bone loss.[16,17] Compared to the areas with thin mucosa, when mucosa was thickened with membranes on the areas where soft tissue thickness is 2 mm or less, a statically meaningful less marginal bone loss was observed.[16,17]

Sizes of the defect determine the used method and graft type. As a basis, grafts divide into two as free and pedicle grafts on the augmentation of soft tissues; free soft tissue grafts and pedicle soft tissue grafts.[11]

The connection of the graft with the donor site is completely cut off on free soft tissue grafts. Free gingival graft, connective tissue graft, interpositional grafts, onlay grafts, onlay-interpositional graft combination and noncellular dermal matrix application are the methods used in soft tissue augmentation. The connection of the graft with the donor site is not cut off on pedicle soft tissue grafts. Defected adjacent area or palatal area can be used as the donor site. Roll method or vascularized interpositional periosteal connection tissue graft technique are frequently used in soft tissue augmentations.[18]

Amount of keratinized mucosa

In a study conducted by Bengazi et al. on five dogs in 2013, according to the examination results of implant and peri-implanter tissues, more bone resorption was observed in the implants surrounded with alveolar mucosa than the ones surrounded with keratinized mucosa.[19] According to a review made in 2012, it was concluded that the effects of the presence or absence of keratinized mucosa are limited to providing tissue stability. Half of the analyzed journals say that plaque score and the bleeding index were observed in individuals who have keratinized mucosa less than 2 mm, 8 of 10 reports have shown that there is no meaningful difference in the probing depth.[20] In clinical practice, a keratinized tissue width of ≥ 2 mm is considered adequate, and a width of < 2 mm is considered inadequate. The accepted knowledge is that adequate keratinized tissue will improve plaque control in the region and provide optimum aesthetics. However, there is no consensus on the effect of the width of the keratinized tissue on the health of the periimplant tissues.[21] In the study of Bouri et al. on 200 implants, the relationship between keratinized mucosal width and peri-implant bone loss was investigated. According to the results of the study, an increase in the width of the keratinized mucosa around the implant indicates less soft tissue inflammation and less marginal bone loss.[22] The results of a more recent clinical trial published by Shimomoto et al. in 2021 also suggest that the width of keratinized tissue increases periimplant bone stability.[23] On the other hand, Roccuza et al., in their retrospective study published in 2015 with 10 years of follow-up, concluded that even if the width of

the keratinized tissue is inadequate, this condition can be tolerated with good oral care.[24] According to the study of Kim et al. in 2009, inadequate keratinized tissue width around the implant does not have a definite negative effect on poor oral hygiene and soft tissue health. However, in the same study, it was added that the lack of keratinized tissue has an effect on gingival recession and marginal bone loss.[25]

Peri-implanter mucosal thickness and marginal bone loss

In 1996, Lindhe and Berglundh showed in the study they have conducted that keratinized mucosa thickness affects the bone stability around the implant. With this study, implant success and the importance of soft tissue thickness in protecting marginal bone were determined.[10] Based on this data, soft tissue thickness's effect on bone stability around the implant has been analyzed. Linkevicius et al. examined the effect of mucosal thickness on marginal bone loss on 26 patients and 65 implants in 2009. In the study, 32 implants were placed as 2 mm supra-crestal, and the other 32 were placed as bone level. Mucosal thicknesses were classified as thin, medium and thick. Crestal bone changes were measured at the end of a one-year follow-up. On average, the thin mucosa showed bone loss of 1.35 mm, medium mucosa 0.32 mm and thick mucosa of 0.12 mm. It has been concluded that initial mucosa thickness may affect the amount of crestal bone loss in implants placed as supracrestal form.[26] In another study by the same researchers, the mucosal thicknesses of the implant-placed regions are divided as more than 2.5 mm and less than 2.5 mm. Nine implants are placed in thin mucosal areas, and 14 implants are placed in thick mucosal areas as 2 mm supracrestal. 23 implants were placed as control groups on the crestal level. The measurements found that the marginal bone loss in the thin mucosa was more than the thick mucosa. It is also stated by the researcher that supracrestal implant placement should be avoided in areas of thin mucosal thickness.[27] Similarly, in a 2-year follow-up study on 79 edental patients in 2012 by Vervaeke et al. that there may be more marginal bone loss in patients or areas with insufficient soft tissue.[28]

In 2014, Linkevicius et al. studied the effects of soft tissue thickness on marginal bone change in implants with platform-switch design. In the study where 80 bone-level implants are used, the areas to be implanted are divided into two groups as thin (less than 2 mm) and thick (2 mm or more), depending on the mucosa thickness. On the marginal bone measurements at the end of 1 year, a loss of bone of 1.17 mm in thin mucosal thickness and 0.21 mm in thick mucosal thickness was seen. Depending on the measurements, researchers concluded that the platform switch implant-abutment connection design will not be sufficient to maintain the crestal bone level in individuals with a thin mucosal biotype. The use of platform-switch design in individuals with thick mucosal biotype is said to have significantly reduced bone loss.[29]

It was examined by Weisner et al. in 2010 to see if the thickening of soft tissue by augmentation could have an effect on marginal bone loss. After 12 months of follow-up, the average marginal bone loss in soft tissues where augmentation was applied was determined to be 0.8 mm and 0.6 mm in non-applied regions.[16] In 2020, Puzio et al. conducted a study on patients with implant indication on mucosal regions by applying soft tissue augmentation again. For augmentation, xenogenic collagen matrix or connective tissue graft were used. Patients who have undergone a soft tissue augmentation procedure are also divided into subgroups based on the application being performed before or after implantation. In the 12-month follow-up period study, 0.5 mm bone loss was observed in the thin mucosal and non-augmented patient group, while the loss was recorded as 0.4mm in the group with soft tissue augmentation connective tissue graft and pre-implanted. According to the results of this study, increased thickness of soft tissue was associated with less marginal bone loss.[17]

In a retrospective study conducted by Burschi et al. in 2014 on 120 patients and 135 implants, all implants

were placed in areas where the mucosal thickness was 3.0 mm. 1.20 mm bone loss was observed after 1 year of follow-up, while at the end of the 3rd year, 1.09 mm bone gain was realized.[30]

Jeong et al. conducted a prospective study in 2011 on 241 patients and 432 implants. In the study, the mucosal thickness was divided into two as less than 3.0 mm and more than 3.0 mm. 318 implants were located in areas with less than 3.0 mm mucosal thickness, and 114 implants were located in areas with 3.0 mm and more thickness. The marginal bone loss in the thin mucosa was found on average 0.3 ± 0.2 mm and 0.3 ± 0.6 mm in thin mucosa after 1 year of follow-up. There was no significant difference between the two groups as marginal bone loss amounts.[31]

The study conducted by Canullo et al. in 2017, compared the marginal bone loss of the areas covered with thick and thin mucosa after 1st and 3rd year. While thin mucosa showed a loss of 0.27 mm at the end of the 1st year and 0.35 mm at the end of the 3rd year, the end of the 1st year in the thick mucosa was calculated as 0.17 mm and 0.11 mm on the 3rd year.[32]

In the study conducted on 70 patients and 70 implants in 2019, Spinato et al. examined the effect of both mucosal thickness and abutment height on bone loss. After 12 months of follow-up time, they observed bone loss of 0.67 mm in 1 mm abutment usage, 0.35 mm in 3 mm abutment usage in thin mucosa; and a bone loss of 0.70 mm in 1 mm abutment usage, 0.33 mm in 3 mm abutment usage in thick mucosa.[33]

Pazmino et al. followed the 12-months bone loss in thin and thick mucosa on a total of 26 patients in 2020. In the final radiographic measurements, a bone loss of 1.7 mm in thin mucosa and 1.59 mm in thick mucosa was measured.[24]

In 2021, Gharpure et al. examined the effects of mucosal thickness on the development of peri-implantitis on 63 patients and 195 implants. In the study with a follow-up period of 6.9 ± 3.7 years, perimplantitis and periimplant mucositis were detected at a higher rate in implants placed in thin mucosa. In the study, where the focal point is not a marginal bone loss but also radiographic data is analyzed, marginal bone loss in the fine mucosa was higher than the thick mucosa, but the difference between them was not statistically significant.[35]

Discussion

Dental implants are seen as materials that can mimic the root of the teeth as close to natural as possible.[1] They provide to eliminate the many disadvantages of tooth-supported stable and removable prostheses. In addition to their advantages, the maintenance of dental implant treatments and their ability to maintain their functions with health can be considered a common concern in many branches of dentistry. A successful dental implant and implant conformation represent different clinical tables. Implant conformation refers to the presence of the dental implant in the mouth.[26] In the past 20 years, many studies have been conducted by researchers, clinicians and implant manufacturers to improve dental implant success. The risk factors that have been effective in dental implant losses and failures have been investigated.

Alberktsson et al. have been diagnosed the periimplantitis at a rate of 2.7% in the 10-year follow-up of modern implants in their study published in 2017. With the aim of increasing the success of implant treatment, reducing or preventing early marginal bone loss has been the focus of our study. Marginal bone loss is examined in the early and late periods. Bone loss seen in the first 1 year is a treatment complication and is usually aseptic. Marginal bone loss seen after the first year is about pathology.[37] Factors that cause marginal bone loss include premature loading, micro-spacing formation, infection, traumatic surgery, cement residue around implant-top prosthetics, reorganization of biological range and soft tissue thickness.

A gap of micron width occurs in the connection caused by the healing head or abutment on the implants placed. This gap, which is inevitably occurring, has been shown to be associated with marginal bone loss and inflammatory cell infiltration.[38,39] The contact or proximity of the micro-range to the crestal bone trig-

gers marginal bone repression. Therefore, it is recommended that two-stage implants are not positioned below 1 mm or 1 mm bone level.[30]

The effect of the platform-switch implant abutment design on marginal bone loss is a highly researched topic. However, the studies have not been combined at a common point, and there are conflicting results. Lazzara and Porter used large implants and narrow-sized abutments and radiologically monitored marginal bone conditions in their study in 2006. They said that the marginal bone was better preserved than the horizontal-match implant-abutment connection design as a result of the follow-up.[41] The multiple studies on this new implant-abutment connection concept have not found a statistically significant difference if the mucosal thickness is less than 2 mm.[42,43]

Linkevicius et al. said that the platform switch implant-abutment design may not produce a successful result in thin mucosa in their study published in 2010. In the study using a total of 12 implants, six implants were selected as platform-switch and six implants were selected as horizontal-match. All implants were placed in a thin mucosa of 2 mm or less, and there was no statistically significant difference between the measurements made in the two groups.[44] In a study conducted by the same researchers in 2014, the platform switch implant-abutment connection design was implemented in individuals with different mucosal thicknesses. In the study where 80 bone-level implants are used, the areas to be implanted are divided into two groups as thin (less than 2 mm) and thick (2 mm or more), depending on the mucosa thickness. Depending on the radiological measurements, researchers concluded that the platform switch implant-abutment connection design will not be sufficient to maintain the crestal bone level in individuals with a thin mucosal biotype. The use of platform-switch design in individuals with thick mucosal biotype is said to have significantly reduced bone loss.[29] In both studies conducted by the same researchers, the history of periodontitis, cigarette habit, diabetes, alcoholism and the use of medication to retard wound recovery were eliminated in the selection of patients. To say that the platform-switch design will not work in thin mucosa, longer-lasting follow-up and further research are needed. Furthermore, it is not possible to generalize the statistical result obtained because the number of implants followed is very small. A more recent study of Puzio et al. using 75 platform-switch implants in 2020 can actually be interpreted in a similar way. The study evaluated 1 year of marginal bone loss in cases of soft tissue augmentation has applied and not applied. In the group with soft tissue augmentation before implantation, statistically less marginal bone loss was detected than the group with thin mucosa and no soft tissue augmentation. It is possible to read these results through thin mucosa as platform-switch design cannot provide superior or equal to platform-switch design with thick mucosa.[31]

There are some limitations that prevent us from accepting the potential impact in most of the studies when the current literature on the effect of initial soft tissue thickness on marginal bone loss is examined. Many of the studies in the current literature contain heterogeneity. The inclusion and exclusion criteria may have caused patient selection bias. It is not possible to generalize the results to the entire community, especially because diabetes, cigarettes and periodontitis are the exclusion criteria in many studies. Because most of the work that meets the inclusion criteria is the same, the possibility of taking sides increases. The fact that most of the work in the literature has been done by the same researcher reduces objectivity to the subject. In addition, marginal bone loss was evaluated only as mesial and distal, and no facial and lingual bone loss assessment was performed. However, the loss of bone around the implant can affect all surfaces.

Studies with the longest follow-up period in the literature are the studies of Canullo et al. in 2017 and Bruschi et al. in 2014. In both studies, radiographic bone changes were followed for 3 years.[30,32] Other than these studies mentioned, the published studies were on average based on 12 months of data. Studies with longer follow-up times are needed to ensure the effectiveness of the mucosal thickness on marginal bone loss.

Conclusion

» Mucosal thickness is seen as not only a provider for aesthetic and plaque control around the implant but also as a possible factor to prevent marginal bone loss.

» Studies with a longer follow-up period, examined on larger populations or multicenter researches are needed for more accurate results.

» Clinical effects of the studies which show differences and say that mucosal thickness is an efficient factor on marginal bone loss around the implant are argumentative.

» It should not be forgotten that osteonecrosis around the implant is a multifactorial and complex process, and it is not possible to tie it with one clinical condition. Inclusion and exclusion criteria in the following studies should be determined in view of these factors.

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Final approval of the version to be published: BY, MT

Table 1. Original articles investigating the effect of soft tissue thickness on peri-implant bone loss between 2009 and 2020

Article	Mucosal thickness	n	Implant number	Control group	Test group	Follow peric
Linkevicius 2009	<2.5 mm ≥2.5 mm	19	thin: 9 thick: 14 (23 control)	bone-level	2 mm supra-crestal	12 mon
Linkevicius 2009	thin: ≤2 mm medium: 2.01-3.00 mm thick: ≥ 3 mm	26	12 12 12 12 8 8	bone-level	supra-crestal	12 mon
Linkevicius 2010	<2 mm	10	control: 6 test: 6	horizontalmatch	platform-switch	12mon
Jeong 2011	<3 mm ≥3 mm	241	318 114	thick mucosa	thin mucosa	12 mon
Linkevicius 2013	A: <2 mm B: 2 mm +membrane C: ≥2 mm	103		thick and thin +membrane	thin mucosa	12 mon
Linkevicius 2013	T1≤2 mm T2≥2 mm C <2 mm + membrane	97	33 32 32	thin+membrane	thin mucosa	12mon
Linkevicius 2014	<2 mm ≥2 mm	80	40 40	thick mucosa	thin mucosa	12 mon
Linkevicius 2015	≤2 mm	30	30: PS 30: LM	laser micro.	platform switch	12 mon
Van Eekeren 2015	A: 2 mm or less B:more than 2 mm	33	A: k: 17 sk: 15 B: k: 20 sk: 22	2.5 mm supra	crestal	12 mon
Bhat 2015	<2 mm ≥2 mm	20	33	thick mucosa	thin mucosa	12 mon

Table 1. Continued

Article	Mucosal thickness	n	Implant number	Control group	Test group	Follow peri
Puzio 2020		57	75	15 Implants (without augmentation) GROUP-I	15 Implants (pre-implantation augmentation) GROUP-II 15 Implants (post-implantation augmentation) GROUP-III	12 mon
Pazmino 2020	thin ≤2.0 mm thick >2.0mm	26	thin: 13 thick: 13	thick mucosa	thin mucosa	12 mon
Weisner 2010	with augmentation: 3.20 mm Control: 1.9 mm	10	test: 10 control: 10	without augmentation	with augmentation	12 mon
Spinato 2019	thin ≤2.0 mm thick >2.0 mm	70	70	thick (B1 - B3)	thin (A1 - A3)	12 mon
Bruschi 2014	thick: 3.0 mm	120	135			3 years
Canullo 2017	thin ≤2.0 mm thick >2.0 mm	26	68	thick	thin	3 years

n, Number of patients

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