sciendo

PROCEEDINGS OF THE LATVIAN ACADEMY OF SCIENCES. Section B,
Vol. 77 (2023), No. 5/6 (746/747), pp. 239–243.

DOI: 10.2478/prolas-2023-0034

Original Paper

INFLUENCE OF MUCOSAL TISSUE THICKNESS ON PERI-IMPLANT BONE STABILITY: RETROSPECTIVE RADIOLOGICAL STUDY

Ingus Arnolds Apse[1,2,3], Rihards Lācis[2,3], Alīna Gončarova[2,3], Ģirts Šalms[2,3], Ilze Akota[2,3], and Laura Neimane[1,2,3,#]

[1] Baltic Biomaterials Centre of Excellence, Headquarters at Rīga Technical University, 3 Pulka Str., Rīga, LV-1007, LATVIA

[2] Institute of Stomatology, Rīga Stradiņš University, 16 Dzirciema Str., Rīga, LV-1007, LATVIA

[3] Faculty of Dentistry, Rīga Stadiņš University, 20 Dzirciema Str., Rīga, LV-1007, LATVIA

[#] Corresponding author, laura.neimane@rsu.lv

Communicated by Isaak Rashal

Gradual bone loss around the implants is an ongoing concern. Mucosal tissue thickness is considered as a contributing factor that influences bone remodelling after implantation. It has been suggested that tissue thickness thinner than 2.5 mm may contribute to more peri-implant bone loss, eventually affecting implant bone stability. Measuring mucosal thickness prior to surgery may be a predictor of the bone changes and could modify the surgical methods. In this study mucosal tissue thickness was measured retrospectively on radiographs before implant insertion, one year and at least three years after implantation. Within the limits of this study, no influence of initial mucosal tissue thickness on long term peri-implant bone stability was found.

Keywords: *mucosal tissue thickness, crestal bone, peri-implant bone stability.*

INTRODUCTION

Dental implants have become a reliable tool for replacement of missing teeth. Peri-implant bone stability is considered to be an important factor for implant stability, longevity and prevention of peri-implantitis. A thicker mucosa prior to implant placement is expected to show less peri-implant bone loss after implantation, which has been supported by animal studies (Berglundh and Lindhe, 1996) and up to one-year-long clinical studies within small groups with well-motivated and controlled subjects (Linkevicius *et al.,* 2009). Measuring mucosal tissue thickness before surgery may predict bone changes in the short term, however, long-term results may differ (Puisys *et al.,* 2019).

Furthermore, daily loading, prostheses, implant design and patient's habits are implicated in events of implant long-term survival.

Intra-oral radiological investigation is a non-invasive method where changes of different tissue can be evaluated at different time spans. The paralleling technique is a reproducible method where images can be compared at different time points.

The aim of this radiographic retrospective study was undertaken to test the relationship of mucosal tissue thickness on long-term peri-implant bone changes.

MATERIALS AND METHODS

Patients for this study were retrospectively selected from the database of a private dental clinic in Rīga, Latvia. Patients older than 18 years, generally healthy, with implants placed in upper jaw premolar region in the period between 1998 to 2014 were selected. Exclusion criteria were known osteoporosis, diabetes, compromised immune system and on-going oncological treatment. Smokers were not excluded from the study.

Fifty selected patients had a pre-surgical intraoral radiograph no more than one month before implant surgery, a

post-surgical intraoral radiograph up to one year after surgery and had a follow-up intraoral radiograph after a minimum of three years after surgery. Patients in the radiograph evaluation stage were excluded if implant threads were unclear, meaning that positioning was not correct; if implant proximity to teeth or adjacent implants was less than 2.0 mm, if the mucosa tissue thickness (MTT) border and/or peri-implant site was unclear for the measurements and if the implant was lost. The single implant site was considered as a study subject.

There were 50 patients selected from the database that corresponded selection criteria and were included in study. There were 22 male and 28 female patients in the study. Patient age was between 36 to 81 years (mean 57.27 ± 10.63 years). A total of 450 measurements of mucosal tissue thickness and 150 measurements of peri-implant bone were performed.

Radiographs were performed with the paralleling technique with Rinn (Dentisply, USA) film holders. Image evaluation and measurements were performed using Digora software (Digora, Soredex, Tuusula, Finland) (Versteeg *et al*., 1997) and CS 3D Imaging software (Carestream Dental LLC, Atlanta, US). Measurements were made by three independent experts previously evaluated and calibrated. Each measurement was performed three times. The mean of all three measurements was considered as the final score for each expert. To insure precision of the measurements, significant differences between experts were evaluated for all variables using the Mann–Whitney U test.

To measure mucosal tissue thickness, the implant position was established in post-operative x-ray from the midline of the implant and closest tooth. The distance was then set in the pre-operative radiograph and labelled. Within 3.5 mm from both sides of the midline, MTT was measured three times by each expert with a space of 1 mm between each measurement (Fig. 1). The subjects were divided into two groups based on pre-operative mucosal thickness: group 1 – mucosal thickness was less than 2.5 mm; group 2 – mucosal thickness was 2.5 mm and more.

The peri-implant bone (PIB) level was measured in post-surgical radiographs on a perpendicular line from the implant abutment junction (IAJ). Perpendicular depth measurements from IAJ line to the bone level were measured. In cases when the PIB mesial or distal site was above the IAJ line, measurements above abutment junction were registered as a positive value, but if below the value was registered as negative (Fig. 2).

Measurements were performed on both postoperative radiographs – within one year after surgery and follow-up at least three years after surgery.

Data were analysed using SPSS 15.0 for Windows (SPSS, Chicago, USA) statistical software. The Kolmogorov–Smirnov test was used to establish normality of the data. To evaluate relationships between different measurements the

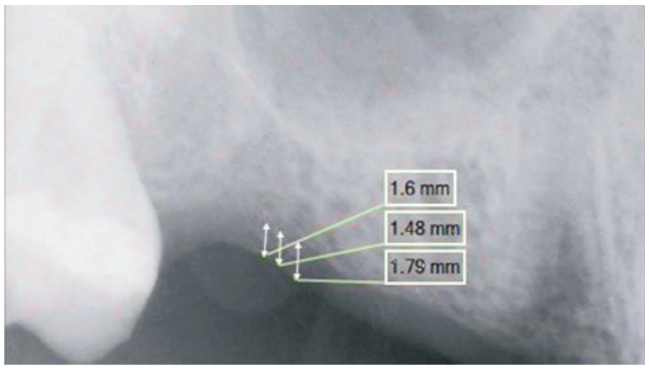

Fig. 1. Mucosal tissue thickness measurement.

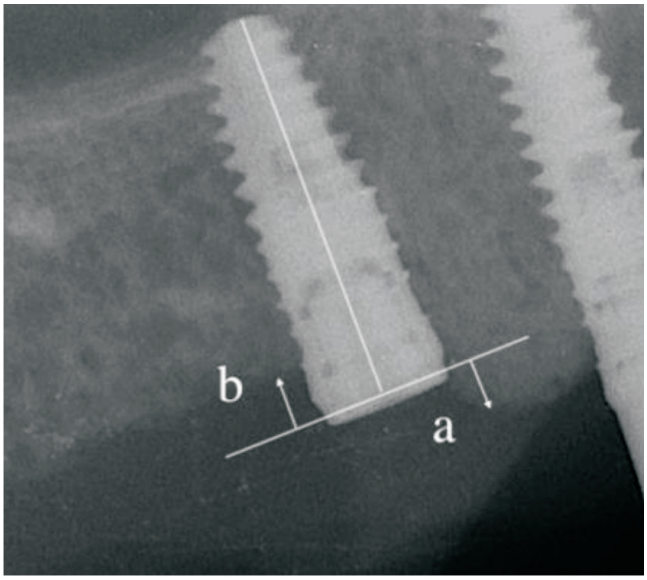

Fig. 2. a, bone level above; b, bone level below.

unpaired Student's t-test, Spearman's correlation, Mann Whitney U test were used. Statistical significance was accepted at $p < 0.05$.

RESULTS

There were 61 subjects included in group 1 and 89 subjects included in group 2. Mucosal tissue thickness (MTT) measurements obtained before operation were compared to peri-implant bone (PIB) level measurement mesially (PIB-M) and distally (PIB-D) in both follow-up groups: after one year and after at least three years after implantation. There were no statistically significant difference between groups (Table 1) nor between follow-up periods within groups ($p > 0.05$).

DISCUSSION

The results of this study showed that there was no difference in PIB between the mucosal tissue thickness groups — thin (< 2.5) and thick (≥ 2.5 mm). The strength of this study is that PIB was evaluated more than three years after implantation. In most studies, peri-implant bone level is evaluated radiographically one year after implant placement

Table 1. Measurements between groups

	Group 1 (< 2.5 mm)	Group 2 (≥ 2.5 mm)	*p*
n	61	89	
MTT	1.88 ± 0.05	3.12 ± 0.06	< 0.001
	After 1 year		
PIB-M	0.82 ± 0.13	0.65 ± 0.13	0.168
PIB-D	–0.56 ± 0.15	0 ± 0.09	0.125
	After at least 3 years		
PIB-M	–1.43 ± 0.16	–1.35 ± 0.16	0.230
PIB-D	–1.44 ± 0.14	–1.38 ± 0.16	0.325

MTT, mucosa tissue thickness; PIB-M, peri-implant bone level measurement mesially; PIB-D, peri-implant bone level measurement distally

(Linkevicius *et al.,* 2009; Bhat *et al.,* 2015; Linkevicius *et al.,* 2015; Puisys and Linkevicius, 2015). This is understandable as the mucosa at implant sites undergoes a reduction in thickness from the time of implant placement till the placement of final restorations that usually occur in the time span of one year. The placement of the final restorations and then end of active therapy leads to a rebound of the tissue thickness. That is why the sites with thicker tissues preoperatively are expected to have a lesser bone loss and have better rebound as compared to thinner tissues. However, preoperative mucosal tissue thickness is not the only variable that might influence the peri-implant bone level. Confounding variables that should be evaluated simultaneously with mucosal tissue thickness are surgical trauma, vertical implant placement, type of connection and/or type of prosthetic retention and smoking (Rammelsberg *et al.,* 2012; Di Gianfilippo *et al.*, 2020).

Several studies have evaluated mucosal tissue thickness radiographically before surgery. Precision of radiographic evaluation may be questioned as the mucosal edge may be difficult to discern (Bouri *et al.*, 2008; Linkevicius *et al*, 2009; Vervaeke *et al.*, 2014; Puisys and Linkevicius, 2015; Canullo *et al.*, 2017). However, the use of three independent measurements may reduce this error in measurement. More recent studies evaluate soft tissue thickness in preoperative cone beam images (Kaminaka *et al.*, 2015; Munakata *et al.,* 2021). Munakata *et al*. their study found that in both jaws the mucosa was the thickest in the anterior region, followed by the premolar and molar regions. Additionally, comparing the premolar and molar regions, the mucosal thickness in the maxilla was significantly greater than that in the mandible. They found no statistical difference between these measurements in maxilla and between genders. Considering the wide use of cone beam computed tomography in the maxillofacial region, more studies in mucosal thickness evaluation are expected in the near future. In our study we measured mucosal tissue thickness in the maxillary premolar region because of easier parallel positioning of film holder were expected, which would cause less image distortion.

In this study there was no significant difference in the bone level around implants and mucosal tissue thickness prior to implantation. This was supported by a prospective clinical trial (Garaicoa-Pazmino *et al*., 2021). These results are similar to those found in several studies investigating an association between mucosal tissue thickness and bone level changes, but are in contrast with other studies. A systemic review published by Akcali *et al.,* 2016 concluded that there was insufficient evidence to confirm that there was difference in peri-implant bone loss between sites with thin and thick initial mucosal thickness. The reason for that is lack of well-designed controlled clinical studies (Akcali *et al.,* 2017). There was a systemic review and meta-analysis published concluding that initially thicker peri-implant soft tissues have less peri-implant bone loss in the short term (Suarez-Lopez Del Amo *et al.,* 2016). However, meta-analysis was based on data from two studies performed by the same authors on the same patient group (Linkevicius *et al.,* 2009; Linkevicius *et al.,* 2009). More recent research support a correlation between mucosal tissue thickness prior to implantation and peri-implant bone loss. However, there was found no effect on implant survival or the occurrence of biological or aesthetic complications and it was recommended that research was carried out for longer period that one year. There might be a different threshold for mucosal thickness proposed (Di Gianfilippo *et al.,* 2020; Bienz *et al.,* 2022). Moreover, Puisys *et al.*, published case reports where initially bone loss was found within the first year but after two years radiologically there was remineralisation of the peri-implant bone, suggesting that one-year studies might be not enough to evaluate implant stability (Puisys *et al.,* 2019). A different study with 2768 implants inserted during a fifteen-year period there found that during the healing period and first year after bridge fixation, marginal bone loss was 1.5 mm. Afterwards, bone loss was reported to be 0.1 mm annually (Adell *et al.,* 1981).

Smoking is a well-known hazard effect on general health. This habit influences implant healing and survival (Moy *et al.,* 2005; Moraschini *et al.,* 2015; Negri *et al.,* 2016). It has been proven that the implant survival rate in mandibular bone is higher compared to maxilla. A statistically significant difference was found in implant survival between both jaws not only among smokers but also in non-smokers. In smokers the difference was greater (Kourtis *et al.,* 2004). There are also studies supporting that smoking significantly affect only implants inserted in maxilla, but this can be questioned as there are fewer such studies performed in mandibular bone (Chrcanovic *et al*., 2015). The risk of implant failure was found to increase with an increase number of cigarettes smoked per day (Naseri *et al.,* 2020). In our study smokers were not excluded as a separate group as data about smoked amount was not available and only a few subjects reported to be smokers.

As this is a retrospective radiographic analysis, we did not have information of the type of mucosa surrounding the dental implants. One can surmise that the maxillary arch was endowed with more keratinized mucosa.

CONCLUSION

Within the limits of the present study there was no significant effect of initial mucosal tissue thickness on long-term peri-implant bone stability.

ETHICS

The protocol for this study was approved by Rīga Stradiņš University Ethical Committee (No. 2-PEK-4/397/2022).

ACKNOWLEDGEMENTS

I. A. Apse and L. Neimane acknowledge financial support from European Union's Horizon 2020 research and innovation programme under the grant agreement No. 857287.

The authors acknowledge Professor Dr. Pēteris Apse and Dr. Artūrs Paparde for consultation.

REFERENCES

Adell, R., Lekholm, U., Rockler, B., Brånemark, P. I. (1981). A 15-year study of osseointegrated implants in the treatment of the edentulous jaw. *Int. J. Oral Surg*., **10** (6), 387–416. DOI: 10.1016/s0300-9785(81)80077-4.

Akcalż, A., Trullenque-Eriksson, A., Sun, C., Petrie, A., Nibali, L., Donos, N. (2017). What is the effect of soft tissue thickness on crestal bone loss around dental implants? A systematic review. *Clin. Oral Implants Res*., **28** (9), 1046–1053. DOI: 10.1111/clr.12916.

Berglundh, T., Lindhe, J. (1996). Dimension of the periimplant mucosa. Biological width revisited. *J Clin. Periodontol.,* **23** (10), 971–973. DOI: 10.1111/j.1600-051x.1996.tb00520.x

Bienz, S. P., Pirc, M., Papageorgiou, S. N., Jung, R. E., Thoma, D. S. (2022). The influence of thin as compared to thick peri-implant soft tissues on aesthetic outcomes: A systematic review and meta-analysis. *Clin. Oral Implants Res*., **33** (23), 56–71. DOI: 10.1111/clr.13789.

Bhat, P. R., Thakur, S. L., Kulkarni, S. S. (2015). The influence of soft tissue biotype on the marginal bone changes around dental implants: A 1-year prospective clinico-radiological study. *J. Indian Soc. Periodontol*., **19** (6), 640–644. DOI: 10.4103/0972-124X.168489.

Bouri, A. Jr., Bissada, N., Al-Zahrani, M. S., Faddoul, F., Nouneh, I. (2008). Width of keratinized gingiva and the health status of the supporting tissues around dental implants. *Int. J. Oral Maxillofac. Implants,* **23** (2), 323–326.

Canullo, L., Camacho-Alonso, F., Tallarico, M., Meloni, S. M., Xhanari, E., Penarrocha-Oltra, D. (2017). Mucosa thickness and peri-implant crestal bone stability: A clinical and histologic prospective cohort trial. *Int. J. Oral Maxillofac. Implants*, **32** (5), 675–681. DOI: 10.11607/jomi.5349.

Chrcanovic, B. R., Albrektsson, T., Wennerberg, A. (2015). Smoking and dental implants: A systematic review and meta-analysis. *J. Dent.,* **43** (5), 487–498. DOI: 10.1016/j.jdent.2015.03.003.

Di Gianfilippo, R., Valente, N. A., Toti, P., Wang, H. L., Barone, A. (2020). Influence of implant mucosal thickness on early bone loss: A systematic review with meta-analysis. *J. Periodontal Implant Sci*., **50** (4), 209–225. DOI: 10.5051/jpis.1904440222.

Garaicoa-Pazmino, C., Mendonça, G., Ou, A., Chan, H.L., Mailoa, J., Suárez-López Del Amo, F., Wang, H. L. (2021). Impact of mucosal phenotype on marginal bone levels around tissue level implants: A prospective controlled trial. *J. Periodontol.,* **92** (6), 771–783. DOI: 10.1002/JPER.20-0458. Epub 2020 Nov 11. PMID: 33107977.

Kaminaka, A., Nakano, T., Ono, S., Kato, T., Yatani, H. (2015). Cone-beam computed tomography evaluation of horizontal and vertical dimensional changes in buccal peri-implant alveolar bone and soft tissue: A 1-year prospective clinical study. *Clin. Implant Dent. Relat. Res.,* **17** (2), 576–585. DOI: 10.1111/cid.12286.

Kourtis, S. G., Sotiriadou, S., Voliotis, S., Challas, A. (2004). Private practice results of dental implants. Part I: Survival and evaluation of risk factors. Part II: surgical and prosthetic complications. *Implant Dent.,* **13** (4), 373–385. DOI: 10.1097/01.id.0000148564.88384.de.

Linkevicius, T., Apse, P., Grybauskas, S., Puisys, A. (2009). Reaction of crestal bone around implants depending on mucosal tissue thickness. A 1-year prospective clinical study. *Stomatologija*, **11** (3), 83–91.

Linkevicius, T., Apse, P., Grybauskas, S., Puisys, A. (2009). The influence of soft tissue thickness on crestal bone changes around implants: A 1-year prospective controlled clinical trial. *Int. J. Oral Maxillofac. Implants,* **24** (4), 712–719.

Linkevicius, T., Puisys, A., Steigmann, M., Vindasiute, E., Linkeviciene, L. (2015). Influence of vertical soft tissue thickness on crestal bone changes around implants with platform switching: A comparative clinical study. *Clin. Implant Dent. Relat. Res.,* **17** (6), 1228–1236. DOI: 10.1111/cid.12222.

Moraschini, V., Poubel, L.A., Ferreira, V. F., Barboza Edos, S. (2015). Evaluation of survival and success rates of dental implants reported in longitudinal studies with a follow-up period of at least 10 years: A systematic review. *Int. J. Oral Maxillofac. Surg*., **44** (3), 377–388. DOI: 10.1016/j.ijom.2014.10.023.

Moy, P. K., Medina, D., Shetty, V., Aghaloo, T. L. (2005). Dental implant failure rates and associated risk factors. *Int. J. Oral Maxillofac. Implants*, **20** (4), 569–577.

Munakata, M., Nagata, K., Sanda, M., Kawamata, R., Sato, D., Yamaguchi, K. (2021). Variations in vertical mucosal thickness at edentulous ridge according to site and gender measured by cone-beam computed tomography. *Int. J. Implant. Dent.,* **12** (7), 34. DOI: 10.1186/s40729-021-00319-w.

Naseri, R., Yaghini, J., Feizi, A. (2020). Levels of smoking and dental implants failure: A systematic review and meta-analysis. *J. Clin. Periodontol*., **47** (4), 518–528. DOI: 10.1111/jcpe.13257.

Negri, B. M., Pimentel, S. P., Casati, M. Z., Cirano, F. R., Casarin, R. C., Ribeiro, F. V. (2016). Impact of a chronic smoking habit on the osteo-immunoinflammatory mediators in the peri-implant fluid of clinically healthy dental implants. *Arch. Oral Biol*., **70**, 55–61. DOI: 10.1016/j.archoralbio.2016.05.014.

Puisys, A., Auzbikaviciute, V., Minkauskaite, A., Simkunaite-Rizgeliene, R., Razukevicius, D., Linkevicius, R., Linkevicius, T. (2019). Early crestal bone loss: Is it really loss? *Clin. Case Rep*., **27** (10), 1913–1915. DOI: 10.1002/ccr3.2376.

Puisys, A., Linkevicius, T. (2015). The influence of mucosal tissue thickening on crestal bone stability around bone-level implants. A prospective controlled clinical trial. *Clin. Oral Implants Res*., **26** (2), 123–129. DOI: 10.1111/clr.12301.

Rammelsberg, P., Schmitter, M., Gabbert, O., Lorenzo Bermejo, J., Eiffler, C., Schwarz, S. (2012). Influence of bone augmentation procedures on the short-term prognosis of simultaneously placed implants. *Clin. Oral Implants Res.,* **23** (10), 1232–1237. DOI: 10.1111/j.1600-0501.2011.02295.x.

Suárez-López Del Amo, F., Lin, G. H., Monje, A., Galindo-Moreno, P., Wang, H. L. (2016). Influence of soft tissue thickness on peri-implant marginal bone loss: A systematic review and meta-analysis. *J. Periodontol.,* **87** (6), 690–699. DOI: 10.1902/jop.2016.150571.

Vervaeke, S., Dierens, M., Besseler, J., De Bruyn, H. (2014). The influence of initial soft tissue thickness on peri-implant bone remodeling. *Clin. Implant. Dent. Relat. Res*., **16** (2), 238–247. DOI: 10.1111/j.1708-8208.2012.00474.x.

Versteeg, K. H., Sanderink, G. C., Velders, X. L., van Ginkel, F. C., van der Stelt, P. F. (1997). *In vivo* study of approximal caries depth on storage phosphor plate images compared with dental x-ray film. *Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endod*., **84** (2), 210–213. DOI: 10.1016/s1079-2104(97)90071-8.

Received 5 January 2023
Accepted in the final form 30 November 2023

SMAGANAS AUDU BIEZUMA IETEKME UZ ZOBU IMPLANTU BALSTA KAULU STABILITĀTI: RETROSPEKTĪVS RADIOLOĢISKAIS PĒTĪJUMS

Kaula balsta saglabāšana ap zobu implantiem ir svarīgs to ilgmūžības nosacījums. Smaganas audu biezums tiek uzskatīts par nozīmīgu faktoru pēc implantācijas kaula remodelācijā un saglabāšanā. Ir dati, kas liecina, ka smaganas biezums, kas ir mazāks par 2,5 mm, veicinātu lielāku kaula zudumu un implanta stabilitātes zaudējumu. Šajā pētījumā smaganas audu biezums tika mērīts dentālos radioloģiskos izmeklējumos pirms implantu ievietošanas, kā arī gadu un trīs gadus pēc implantu ievietošanas. Pētījuma ietvaros netika konstatēta smaganas audu biezuma ietekme ilgtermiņā uz periimplanta kaula stabilitāti.