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A new method to assess and measure palatal masticatory mucosa by cone-beam computerized tomography

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Abstract

Aim: The aim of this study was to apply a novel method to obtain high-quality images by cone-beam computerized tomography (CBCT) that consistently allowed the determination of the dimensions of the palatal mucosa.

Materials and Methods: Thirty-one patients participated in this study. At the time of the CBCT scanning, the patients wore a plastic lip retractor and wooden spatulas to retract soft tissues away from the teeth and gingiva. The thickness of the palatal mucosa was obtained at forty different locations on each patient.

Results: Retraction of the lips and cheek allowed a clear observation and measurements of the thickness of the palatal masticatory mucosa. The average thickness of the palatal mucosa was 2.92 mm in the canine area, 3.11 mm at the first pre-molar, 3.28 mm at the second pre-molar, 2.89 mm at the first molar and 3.15 mm at the second molar. Statistical differences were observed at different ages and heights of measurements.

Conclusions: A new non-invasive method to consistently obtain high-quality images of the palatal masticatory mucosa is described. Measurements of this mucosa could be obtained at different locations on the palate.

Key words: cone-beam computerized tomography; connective tissue graft; donor area; palatal mucosa; soft tissues

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The palatal masticatory mucosa is the main donor area of soft tissue grafts applied for increasing the dimensions of keratinized mucosa around teeth and implants, covering exposed roots, and increasing localized alveolar ridge thickness (Wennström & Pini Prato 2003). Connective tissue grafts are also well indicated to enhance the probability of complete root coverage when associated with coronally advanced flaps in certain types of gingival recessions (Cortellini et al. 2009; Cairo et al. 2008). Although determination of the thickness of the palatal mucosa would be of great value to better predict the outcome of several surgical procedures, pre-surgical assessment of the thickness of the donor area is greatly overlooked due to a lack of reliable methods for this purpose. Through studies that applied conventional histology in cadavers to determine the thickness of the palatal mucosa (Kydd et al. 1971), one had a general ''idea'' of the best area for graft removal. However, each patient and each area presented variations of the quantity available for removal. Invasive methods, such as the use of needles and periodontal probes, have been described in the literature (Greenberg et al. 1976, Wolf et al. 2004). These methods present a great disadvantage because they require local anaesthesia and are thus commonly performed just before graft removal, not allowing a precise pre-surgical planning of the procedure. A non-invasive method that applies an ultrasonic device has also been described; however, this method presents a certain degree of difficulty to consistently obtain reliable results (Müller et al. 1999).

In a recent retrospective study, images obtained by fan beam computerized tomography (CT) were analysed, and the thickness of different regions of the palatal masticatory mucosa was

Conflict of interest and source of funding statement

The authors declare that there are no conflicts of interest in this study.
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determined on those images (Song et al. 2008. However, a method to consistently obtain images that allowed those measurements to be performed was not described. Cone-beam computerized tomography (CBCT) has been widely used to analyse the maxillofacial region (Scarfe et al. 2006). The CBCT technology offers the dentist high-quality diagnostic images and it has become an essential tool in dentistry. It has been reported that CBCT is not indicated for evaluating soft tissues, and it is considered a tool for exclusively evaluating hard tissues of the maxillofacial complex (Scarfe et al. 2006). However, we have recently reported that CBCT can be applied for visualizing and measuring soft tissues of the dentogingival unit (Januario et al. 2008).

Because of limited knowledge of individual thickness and regional differences of the palatal mucosa, we developed a method based on CBCT technology to consistently visualize and precisely measure the dimensions of the palatal masticatory mucosa. This simple and non-invasive technique requires standard CBCT and materials routinely used in dental offices.

Materials and Methods

Thirty-one patients (11 males and 20 females), ages ranging from 19 to 53 years (mean age of 32 years), were selected for this study. Informed consents were obtained from all the patients and approved by the Ethics Committee of the Medical School of the University of Brasilia, Brazil. The patients presented all maxillary teeth, except the third molars, and the exclusion criteria were: to have undergone surgery for soft tissue removal in the area analysed, history or presence of pathology in the palatal region, teeth with severe morphological alterations, tooth mal-alignment and bone or gingiva loss seen in the CT scans.

The CT scans were performed with the iCAT unit (Imaging Sciences International Inc., Hatfield, PA, USA) and the images were acquired by means of the iCAT software and processed by a computer. At the time of the CT scans, the patients remained seated and had their chins and heads stabilized. Each patient was asked to bite a wooden spatula placed across the mouth at the level of the maxillary and mandibular molars (first and second molars)

Fig. 1. Patient at the time of cone-beam computerized tomography scanning wearing a plastic lip retractor and the wooden spatula to retract the cheeks and tongue from the facial gingiva and palatal masticatory mucosa, respectively.

(Fig. 1). The purpose of the spatula was to separate the maxillary teeth from the mandibular teeth and to prevent the tongue from touching the soft and hard palates during image acquisition. Together with the wooden spatula, a plastic lip retractor was placed in the patient's mouth so that the cheeks did not touch the facial aspects of the teeth, thus also allowing the facial gingiva to be visualized. Acquisition was performed in the maxilla (with volumetric dimension of 6×17 cm) for 40 s with the iCAT tomography acquisition protocol: voxel size: 0.2 mm; Grey scale: 14 bits; focal spot: 0.5 mm; image detector: amorphous silicon flat panel; image acquisition: single 360° rotation. The images were generated in XORAN language and the files of each patient were saved and analysed.

All analyses were performed by the same radiologist as follows: canines, pre-molars and molars (five teeth on the right side and five teeth on the left side) were subjected to measurements. These measurements were performed at four different heights in the palate, i.e., at distances of 2, 5, 8 and 12 mm from the gingival margin. Therefore, four measurements were performed for each tooth (Fig. 2). ANOVA was performed to verify whether there was any statistical difference in the thickness of the palatal mucosa with regard to gender, while the Wilcoxon's sign test was used to compare measurements performed at two different time-points on the images of six patients.

Results

An overview of a representative image showing the result of a CBCT with soft tissue retraction is seen in Fig. 3. By

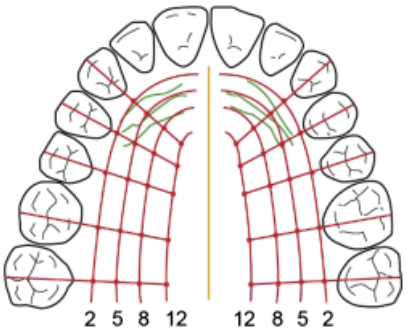

Fig. 2. Measurements of the palatal mucosa were performed from upper canines to second molars on both the right and the left side at 2, 5, 8 and 12 mm from the gingival margin.

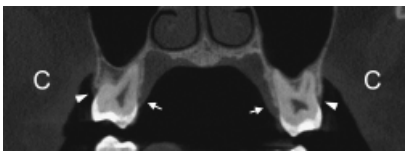

Fig. 3. Representative cone-beam computerized tomography scan showing soft and hard tissues of both facial and palatal aspects of the first maxillary molars. C, cheeks; arrowheads, facial gingiva; arrows, palatal masticaticatory mucosa.

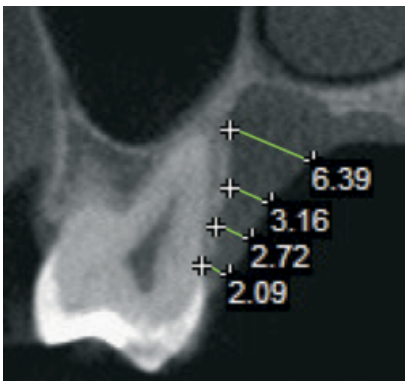

Fig. 4. Representative cone-beam computerized tomography scan showing the precise measurements obtained with the i-CAT software at the positions indicated on Fig. 2.

retracting the soft tissues away from the palate and facial aspect of the teeth, the palatal and facial gingivae are clearly seen. Figure 4 shows a representative image of the measurements performed at four different points, i.e., 2, 5, 8 and 12 mm from the gingival margin. Note that the gingival margin can be easily identified on that image. Interestingly, when an anatomic alteration (bone exostosis at the palatal aspect of the first molar) was present in one of the patients

(Fig. 5), we observed that the palatal mucosa did not show a similar volumetric increase; instead, the palatal mucosa appears to be extremely thin in this area.

Table 1 shows the mean thickness with standard deviations of the palatal mucosa (right and left sides) in different teeth, at different heights of measurement in male and female subjects. In all teeth, the palatal mucosa was thicker at higher measurements (8 and 12 mm) when compared with those closer to the gingival margin (2 and 5 mm). Measurements performed at 2 mm from the gingival margin were similar in all teeth. However, the palatal mucosa was thicker at intermediate heights of measurement (5 and 8 mm) in canines and both pre-molars as compared with the molar teeth. With the exception of the canine, all other teeth presented the thickest palatal mucosa at 12 mm of measurement. The thickness of the palatal mucosa was similar in male and female subjects and a statistical difference was not found ($p = 0.8325$). There was a tendency for a thicker masticatory mucosa to be found in older patients (above 40 years old) as compared with younger patients (below 40 years old). Figure 6 summarizes the results of Table 1 regarding the mean thickness of the palatal mucosa in different teeth and at different heights of measurement. As shown, these measurements were similar on both the right and the left side. Measurements of the thickness of the palatal mucosa were performed at two different time-points on the images of six patients and there was no statistical difference between these measurements (Wilcoxon test, $p = 0.3651$).

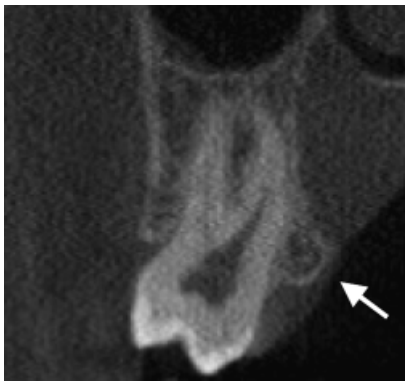

Fig. 5. Cone-beam computerized tomography scan revealing the presence of a palatal bone exostosis in the maxillary molar region and a thin band of palatal masticatory mucosa (arrow).

Discussion

This report describes a non-invasive technique based on CBCT, which consistently produces images that allow the measurement of the dimensions of the palatal masticatory mucosa. This simple technique has several applications in dentistry, especially in Periodontics, Implant Dentistry and Oral Surgery. It is important to mention that this is a quantitative and not a qualitative method, because the differences between the epithelial, fat and connective tissues cannot be seen on the images. Furthermore, an inflamed gingiva would have a similar appearance as a healthy gingiva on the images acquired by CBCT.

The gingiva and the mucosa of the hard palate are two distinct soft tissues and together they represent the masticatory mucosa (Kydd et al. 1971). There is considerable intra-individual and inter-individual variation in the thickness of this mucosa (Müller et al. 2000). Upon clinical examination, the palatal area may not be thick enough, which may preclude this site as a donor area for a connective tissue or a gingival graft. This deficient donor area is oftentimes verified just before graft removal, because pre-surgical examination by sounding under local anaesthesia is commonly avoided. Nevertheless, a few reports have described techniques to augment (Carnio & Hallmon 2005) or manage thin palatal tissue (Bosco & Bosco 2007). The CBCT technique presented here is certainly an excellent tool to better plan and select one of these surgical techniques to manage a thin palatal donor area.

In a previous report, our group demonstrated that a clear visualization of soft and hard tissues of the dentogingival unit was possible by means of CBCT with soft tissue retraction (lips and cheeks) (Januario et al. 2008). In the present report, we applied the same technique with a better retraction of the tongue to visualize the palatal masticatory mucosa (Fig. 1). Up to now, CBCT without retracting soft tissues has been widely used for hard tissues imaging (Mah & Hatcher 2004, Scarfe et al. 2006). In fact, one of the greatest limitations of CBCT has been its incapability of discriminating soft tissues. Kobayashi et al. (2004) reported that this specific limitation of CBCT is due to the low resolution of contrast. However, to perform the acquisitions of this study the iCAT system was used, which is a commercially available and commonly used device. Although the different capacities of several CBCT systems for image acquisition of the palatal mucosa

Table 1. Mean and median thickness with standard deviations of the palatal mucosa in different teeth, different heights of measurement and divided by gender

Height of measurement	C				P1				P2				M1				M2			
	2.0	5.0	8.0	12.0	2.0	5.0	8.0	12.0	2.0	5.0	8.0	12.0	2.0	5.0	8.0	12.0	2.0	5.0	8.0	12.0
All participants ($N = 31$)																				
Mean	1.97	2.97	3.48	3.29	2.07	2.90	3.55	3.93	2.12	2.95	3.85	4.22	2.11	2.34	2.92	4.21	2.22	2.28	3.08	5.02
SD	0.54	0.59	0.69	0.78	0.46	0.54	0.57	0.78	0.35	0.57	0.59	0.71	0.51	0.65	0.73	0.90	0.72	0.77	1.22	1.61
Median	1.98	2.95	3.44	3.33	2.06	2.90	3.50	3.93	2.09	2.96	3.84	4.23	2.06	2.20	2.91	4.02	2.15	2.15	2.97	5.24
Male participants ($N = 11$)																				
Mean	2.11	3.13	3.68	3.58	2.10	2.95	3.70	4.08	2.01	2.95	4.02	4.51	2.06	2.31	2.77	4.09	1.99	2.38	2.60	4.36
SD	0.49	0.57	0.76	0.80	0.61	0.54	0.73	0.96	0.29	0.65	0.72	0.70	0.56	0.61	0.98	0.83	0.43	0.63	1.21	1.55
Median	2.11	3.05	3.64	3.52	2.05	2.96	3.51	4.26	1.99	2.94	4.08	4.54	1.78	2.15	2.56	3.85	1.98	2.26	2.20	4.29
Female participants ($N = 20$)																				
Mean	1.90	2.89	3.36	3.13	2.05	2.87	3.47	3.85	2.18	2.95	3.75	4.06	2.14	2.36	3.01	4.27	2.36	2.23	3.34	5.38
SD	0.56	0.59	0.62	0.73	0.36	0.54	0.46	0.65	0.37	0.53	0.49	0.68	0.48	0.68	0.54	0.94	0.81	0.85	1.16	1.55
Median	1.87	2.90	3.33	3.26	2.06	2.83	3.50	3.78	2.20	2.98	3.74	4.13	2.13	2.31	2.95	4.15	2.16	2.11	3.27	5.48

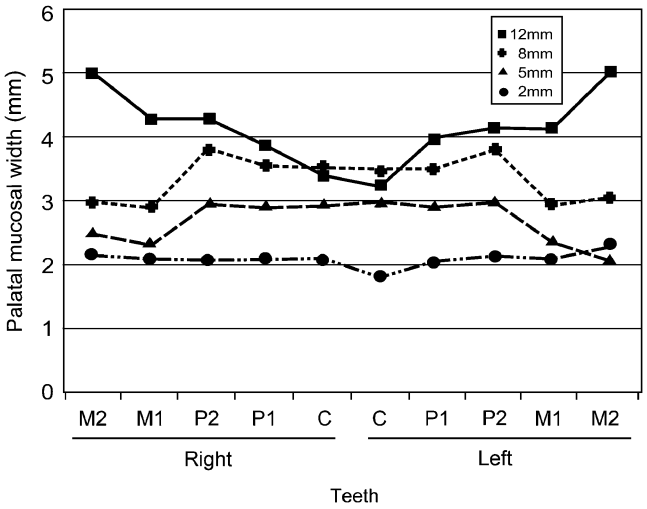

Fig. 6. Mean thickness of the palatal mucosa in different teeth and at different heights of measurement.

were not compared in this study, it is believed that the results of other systems would be similar to those of the iCAT.

Few articles describe different techniques to measure the thickness of palatal masticatory mucosa. Transgingival sounding by means of a periodontal probe has been used for this purpose; however, this method is inconvenient for the patient because it is invasive and must be performed under local anaesthesia (Studer et al. 1997, Wara-aswapati et al. 2001). A non-invasive method that applies an ultrasonic device has also been described (Müller et al. 1999). Although this method is more comfortable for the patient, the authors describe difficulty to consistently obtain reliable results (Eger et al. 1996, Müller et al. 1999). Furthermore, none of the techniques reported so far produce an image of the hard and soft tissues including the palatal mucosa. On the other hand, the technique described in the present study reveals a high-quality image of hard (teeth and bone) and soft (facial and palatal gingiva) tissues and allows measurements of the dimensions and relationships of these structures. A clear visualization of the palatal mucosa is evident in the images (Fig. 4) and a precise measurement of its thickness can be performed. Furthermore, because the aspect ratio of the images obtained by CBCT is 1:1 (Januario et al. 2008, Song et al. 2008) and these images can be saved and printed, repeated measurements can be performed either on the computer screen or on hard copies. It is also important to mention that, due to the nature of the CBCT scan, images of the same region can be obtained at different time-points with the same aspect ratio.

In a recent retrospective study, Song et al. (2008) demonstrated the possibility to measure the thickness of the palatal masticatory mucosa on images obtained by conventional CT (Song et al. 2008). However, a method to consistently obtain images that allowed measurements was not developed or described. Compared with conventional tomography, CBCT presents advantages such as lower radiation, better image quality, greater comfort for the patient and lower cost. Another important factor reported here is the possibility of evaluating both sides of the maxilla in the same image (Fig. 3), providing the dentist with options to choose the side he/she thinks is the best donor area.

In this study, the mean thickness of the palatal mucosa varied according to different regions of the palate. At the level of the canines, the thickness was 2.92 mm; 3.11 mm at the first pre-molar region; 3.28 mm at the second pre-molar; 2.89 mm at the first molar; and 3.15 mm at the second molar. These measurements were similar to those reported in previous studies using other methods to assess gingival thickness (Studer et al. 1997, Müller et al. 1999, 2000, Wara-aswapati et al. 2001). On the other hand, Song et al. (2008) found slightly thicker palatal masticatory mucosa using CT scanning possibly due to an older patient population analysed in their study (Song et al. 2008). In the present study, there was no difference of palatal tissue thickness between males and females. This result was consistent with those of previous studies (Studer et al. 1997, Wara-aswapati et al. 2001) but inconsistent with those of other studies (Östlund 1958, Müller et al. 2000, Song et al. 2008). Our results also show an increased thickness of the palatal mucosa at higher measurements, i.e., the farther away from the gingival margin the thicker the palatal mucosa was in all teeth of all patients. There was a tendency for a thicker palatal mucosa to be found in older patients when compared with younger ones, which is consistent with the findings reported by Song et al. (2008). Finally, significant differences were not observed between the measurements taken at two time-points by the same examiner.

In conclusion, a new non-invasive method to consistently obtain images and measurements of the palatal mucosa is described. This reliable, simple and reproducible method could provide important benefits in planning dental procedures, especially in periodontics, implant Dentistry, and oral Surgery. Further studies on the use of this technique for other applications for soft tissue visualization must be performed.

References

Bosco, A. F. & Bosco, J. M. (2007) An alternative technique to the harvesting of a connective tissue graft from a thin palate: enhanced wound healing. *International Journal of Periodontics and Restorative Dentistry* **27**, 133–139.

Cairo, F., Pagliaro, U. & Niere, M. (2008) Treatment of gingival recession with coronally advanced flap procedures: a systematic review. *Journal of Clinical Periodontology* **35** (Suppl. 8), 136–162.

Carnio, J. & Hallmon, W. W. (2005) A technique for augmenting the palatal connective tissue donor site: clinical case report and histologic evaluation. *International Journal of Periodontics and Restorative Dentistry* **25**, 257–263.

Cortellini, P., Tonetti, M., Baldi, C., Francetti, L., Rasperini, G., Rotundo, R., Nieri, M., Franceschi, D., Labriola, A. & Pini Prato, G. (2009) Does placement of a connective tissue graft improve the outcomes of coronally advanced flap for coverage of single gingival recessions in upper anterior teeth? A multi-centre, randomized, double-blind, clinical trial. *Journal of Clinical Periodontology* **36**, 68–79.

Eger, T., Müller, H. P. & Heinecke, A. (1996) Ultrasonic determination of gingival thickness. Subject variation and influence of tooth

type and clinical features. *Journal of Clinical Periodontology* **23**, 839–845.

Greenberg, J., Laster, L. & Listgarten, M. A. (1976) Transgingival probing as a potential estimator of alveolar bone level. *Journa of Periodontology* **47**, 514–7.

Januario, A. L., Barriviera, M. & Duarte, W. (2008) Soft tissue cone-beam computed tomography: a novel method for the measurement of gingival tissue and the dimensions of the dentogingival unit. *Journal of Esthetic and Restorative Dentistry* **20**, 366–374.

Kobayashi, K., Shimoda, S., Nakagawa, Y. & Yamamoto, A. (2004) Accuracy in measurement of distance using limited cone-beam computerized tomography. *International Journal of Oral and Maxillofacial Implants* **19**, 228–231.

Kydd, W. L., Daly, C. H. & Wheeler, J. B. III (1971) The thickness measurement of masticatory mucosa in vivo. *International Dental Journal* **21**, 430–441.

Mah, J. & Hatcher, D. (2004) Three-dimensional craniofacial imaging. *American Journal of Orthodontics and Dentofacial Orthopedics* **126**, 308–309.

Müller, H. P., Schaller, N. & Eger, T. (1999) Ultrasonic determination of thickness of masticatory mucosa. A methodological study. *Oral Surgery Oral Medicine Oral Pathology Oral Radiology and Endodontics* **88**, 248–253.

Müller, H. P., Schaller, N., Eger, T. & Heinecke, A. (2000) Thickness of masticatory mucosa. *Journal of Clinical Periodontology* **27**, 431–436.

Östlund, S. G. (1958) The effect of complete dentures on the gum tissue: a histological and histopathological investigation. *Acta Odontologica Scandinavica* **16**, 1–40.

Scarfe, W., Farman, A. & Sukovic, P. (2006) Clinical Applications of cone-beam computed tomography in dental practice. *Journal of Canadian Dental Association* **72**, 75–80.

Song, J.-E., Um, Y.-J., Kim, C.-S., Choi, S.-H, Cho, K.-S., Kim, C.-K., Chai, J.-K. & Jung, U.-W. (2008) Thickness of posterior palatal masticatory mucosa: the use of computerized tomography. *Journal of Periodontology* **79**, 406–412.

Studer, S. P., Allen, E. P., Rees, T. C. & Kouba, A. (1997) The thickness of masticatory mucosa in the human hard palate and tuberosity as potential donor sites for ridge augmentation procedures. *Journal of Periodontology* **68**, 145–151.

Wara-aswapati, N., Pitiphat, W., Chandrapho, N., Rattanayatikul, C. & karimbux, N. (2001) Thickness of palatal masticatory mucosa associated with Age. *Journal of Periodontology* **72**, 1407–1412.

Wennström, J. L. & Pini Prato, G. P. (2003) Mucogingival therapy – periodontal plastic surgery. In: Lindhe, J, Karring, T & Lang, NP (eds). *Clinical Periodontology and Implant Destistry*, 4th edition, pp. 576–631. Oxford, UK: Blackwell Munksgard.

Wolf, H. F., Rateitschak, E. M., Rateitschak, K. H., Hassell, T. M. (2004) *Color Atlas of Dental Medicine-Periodontology*, 3rd edition. Stuttgart, Germany: Thieme.

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Clinical Relevance

Scientific rationale for the study: The palatal masticatory mucosa is the main donor area to obtain soft tissue grafts used in different procedures in Periodontics and Implant Dentistry. We describe a non-invasive technique based on CBCT to consistently and predictably measure the thickness of the palatal masticatory mucosa.

Principal findings: Retraction of the lips and cheek allowed a clear observation and measurements of the thickness of the palatal masticatory mucosa. The thickness of the palatal mucosa varied according to teeth.

Practical implications: This reliable and simple method could provide important benefits in planning dental procedures, especially in Periodontics, Implant Dentistry and Oral Surgery.