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ACCURACY OF ORAL MUCOSAL MEASUREMENTS USING CBCT AND BARIUM EMBEDDED DENTURE BASE

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Abstract

Objective The dimensions and relationships of the periodontal structures are vital in various dental specialties. Paper describes a simple, novel, noninvasive and a promising technique which illustrates and validates the possibility of radiographically visualizing and metrically assessing oral hard and soft tissues of the periodontium.

Materials and Methods A total of 14 periodontally healthy, dentate subjects with no severe crowding, rotation, or spacing in the maxilla, and no history of palatal disease or surgery participated in this study. Maxillary impression of the patient made using additional polyvinyl impression material. Maxillary CBCT images of the patients with the barium incorporated denture base in place were obtained using Carestream CS 3D 9300 C machine with the FOV of 5X10 cm at 90 Kvp, 6.3 mA, scanning time 8 secs and angle of rotation 270 degrees. Analysis was done using CS 3D Dental Imaging Software.

Results A strong correlation in the measurements of thickness of the palatal masticatory mucosa by both methods ($r=0.90$; $p<0.01$). Mean palatal masticatory mucosa thickness was 2.74 mm (range: 2.0 to 6.03 mm) on CBCT and on physical measurements it was found to be 2.6 mm (range: 2.0 to 5.03 mm).

Conclusion Barium sulphate dry, white, chalky powder, appears white (radio-opaque) on the X-ray film. Its applications in medicine include barium meal a diagnostic test used to detect abnormalities of the esophagus, stomach and small bowel using X-ray imaging. This coherent property of radio opacity of barium helped us visualize and analyse the oral hard and soft tissues on maxillary CBCT images as well.

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Introduction

The masticatory mucosa consisting of buccal gingiva and the palatal mucosa are two distinct oral soft tissue areas that are considered to be potential donor sites for soft tissue grafts in periodontal plastic surgery [1]. Mucosal thickness in the mid-palatal region is also significant for orthodontic temporary anchorage devices (TADs) because thinner mucosa provides a more stable base for the TAD implantation [2].The thickness of the graft tissue obtained is a significant factor for the success of the procedures like periodontal therapy, root coverage procedures, implant placement etc. Harvesting a graft of even thickness is crucial [3]. It has been shown that patients with thin gingival biotype (<0.7mm) were more likely to experience gingival recession following surgical periodontal therapy, and similarly thick grafts lead to graft rejection or delayed healing [3].

There are relatively few studies investigating the thickness of oral mucosa and most of them have been invasive in nature.Bone sounding or physical measurement methods are direct methods using endodontic reamer and periodontal probe following local anesthetic administration giving reliable results regarding the thickness of the masticatory mucosa [3],[4]. The ultrasonic measurement is less invasive and easy to perform [3]; however, it is technique-sensitive and less reliable, whenever mucosal thickness exceeds 6 mm because of the attenuation of the signal in the tissues and reflection artifacts from adjacent structures [5],[6]. Moreover the non-invasive ultrasonic method produces only low-resolution images depending on anatomic variations. Lately, computed tomography (CT) has been tried to assess the thickness of oral mucosa [7], however the high radiation doses involved may be a hindering factor [8]. Conversely with a lower output and a shorter exposure time, cone-beam computed tomography (CBCT) is a valuable tool for hard maxillofacial tissue imaging and has become an essential tool in dentistry [9]. However, one of the limitations of CBCT is its failure to differentiate soft tissues that has rendered CBCT as an exclusive tool for hard tissue assessment. In this study, an attempt was made to use CBCT along with barium embedded special tray for visualizing and metrically assessing hard and soft oral tissues.

Methodology

Oral Mucosal Measurements

A total of 14 periodontally healthy, dentate subjects with no severe crowding, rotation, or spacing in the maxilla, and no history of palatal disease or surgery participated in this study. Following oral examination and case history recording, maxillary impression of the patient was made using additional polyvinyl impression material, implying selective impression technique. The impression was then poured in cast stone (type IV) according to the manufacturer's instructions and allowed to set. Following trimming of the cast, denture base was fabricated by mixing 1 part of Barium sulphate powder (Chaitanya chemicals, Andhra Pradesh, India) with 3 parts of cold cure clear acrylic polymer following trial and error sequence. The denture base was then fabricated over the cast using dough method sparing the crown of the teeth. Utmost care was taken to ensure that the denture base accurately fitted to the mucosal surface without any air gap in between. It was followed by trimming of the denture base on marginal gingival edges, both on buccal and palatal side to avoid any sharp edges or rough surface causing discomfort to the patient (Fig 1). The coherent property of radio opacity of barium helped us to appreciate the radiographic image of the denture along with its extensions when worn by the patient. These extensions further helped us to assess the thickness of palatal and gingival mucosa at the desired sites

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Maxillary CBCT images of the patients with the barium incorporated denture base in place were obtained using Carestream CS 3D 9300 C machine with the FOV of 5X10 cm at 90 Kvp, 6.3 mA, scanning time 8 secs and angle of rotation 270 degrees. The analysis of the acquired image was done using CS 3D Dental Imaging Software. Since the barium incorporated denture base appears radio opaque the mucosal surface of denture base imitates as the mucosa overlying the maxillary bone as there is complete adherence of the mucosa over the maxillary bone. Following the CBCT scan, the images were visualized through dental imaging software and the thickness of the palatal and gingival mucosa was measured at different sites as the distance between two radioopacities i.e. between the radiopacity of the bone and radioopacity cast by the denture base, at the desired sites(Fig 2,3). Mucosal thickness was recorded to a two decimal points (0.01 mm) at each site on the images.These measurements were later confirmed by transgingival probing using UNG15 probe following local anesthesia with 2% lignocaine HCL injection. The extent of penetration was measured by using a caliper to the nearest 0.1mm.

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Periodontal Pocket Assessment

A total of 14 subjects with chronic periodontitis participated in this study. Following case history and recording of pocket probing depth using Williams probe, barium embedded maxillary denture base was prepared and the patient was exposed to the CBCT scan with the denture base in place using Carestream CS 3D 9300 C machine with the FOV of 5X10 cm (single jaw) at 90 Kvp, 6.3 mA, scanning time 8 secs and angle of rotation of 270 degrees. The analysis of the acquired image was done using CS 3D Dental Imaging Software. On the scan periodontal pocket depth was assessed by measuring the distance from the radio opaque **marginal** outline of **free gingiva (denture base)** to the crest of the alveolar bone at the desired site (Fig 4). Periodontal pocket depth varied between 5-10 mm at varied sites.These measurements were further confirmed clinically using Williams probe and during surgical intervention and was found to be exactly identical.

Gingival Collar Assessment After Implant Placement

Prior to 2nd stage surgery for implants, CBCT scan was made with barium embedded special tray in place using Carestream CS 3D 9300 C machine with the FOV of 5X5 cm at 90 Kvp, 6.3 mA, scanning time 20 secs and the angle of rotation of 270 degrees. The width of the gingiva required was measured as distance between fitting surface of special tray and coronal surface of the implant(Fig 5). This measurement was used to select the appropriate thickness of the free gingival graft for soft tissue augmentation. Results were found to be successful both in terms of stability and esthetic outcomes.

Results

Each site was evaluated via CBCT method and by physical measurements and were then compared and statistically analysed using SPSS v16.0 software. Unpaired t test was used to evaluate the measurement differences. On CBCT mean labial masticatory mucosa thickness was 2.71mm (2mm -3.6mm) and on physical measurements it was found to be 2.6mm (2.1mm -3.6mm).There was a strong correlation in the measurements of thickness of the palatal masticatory mucosa by both methods ($r=0.90$; $p<0.01$). Mean palatal masticatory mucosa thickness was 2.74 mm (range: 2.0 to 6.03 mm) on CBCT and on physical measurements it was found to be 2.6 mm (range: 2.0 to 5.03 mm)(Graph 1). Females had significantly thinner mean masticatory mucosa (2.69 mm) than males (2.92mm) (P <0.001). The thickness of the palatal masticatory mucosa increased with age and varied according to the tooth site.Periodontal pocket assessment was also performed by both methods and the measurements were compared and statistically analysed There was no difference in the readings between the two methods used ($p>0.05$).

Discussion

Barium sulphate is a dry, white, chalky powder that appears white (radio-opaque) on the X-ray film. Its applications in medicine include **barium** meal a diagnostic test used to detect abnormalities of the esophagus, stomach and small bowel using X-ray imaging. This coherent property of radio opacity of barium helped us visualize and analyse the oral hard and soft tissues on maxillary CBCT images as well.

Keratinized Oral Mucosa Assessment

Assessment of the thickness of oral mucosa is vital in various clinical situations e.g. thickness of masticatory mucosa is essential for graft placement in recessed gingiva and recessed peri-implant mucosa and implant treatment planning [10]. The literature search reveals various invasive and non-invasive methods used to assess the mucosal dimensions such as transgingival probing, histologic sections, cephalometric radiographs and CT [11]. Transgingival sounding is inconvenient for the patient because it is invasive in nature and is performed under infiltration local anesthesia, causes distortion of the tissue and it is depends on subjective perception [12]. Non-invasive method such as application of ultrasonic devices is comfortable for the patient, but may not yield reliable results on a consistent basis and is technique sensitive [13]. Quality, quantity and position of the mucosa should be assessed prior to surgery to achieve satisfactory results. Thinner mucosa for graft placement are easily friable and recessed following mechanical trauma and surgical procedures as compared to thicker mucosa. Hence extreme caution has to be exercised during site selection [11]. In our study, we found the CBCT measurements of keratinized mucosa comparable to bone sounding method and hence can be easily adapted. Merits of the method include non-invasive nature, multiple donor site selection, evaluation of regeneration of donor site, gingival biotype and assessment of

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entire thickness of palatal mucosa by a single scan, is cost effective, records can be used for future references and is 100% reproducible. The effective dose to the patient by the above mentioned procedure was found to be around 275 µ Sv which is comparable to intra oral full mouth radiological examination dosage. Comparisons between CBCT images, periapical radiography, and clinical evaluations have demonstrated significant differences in the extent of periodontal defects, and more ever CBCT allows for the observation of all bone defects and better inspection of craters and furcation defects and a 1 : 1 ratio that allows reliable measurements. In addition to the radiation dose, image quality and diagnostic needs should be strongly taken into account.

Periodontal Pocket Assessment

Clinical probing is a prerequisite to complete periodontal assessment. The validity of the measurement is determined by various factors, such as the geometry of the probe, angle of application, force applied besides biological factors such as inflammation of the tissue which impact the degree of probe penetration [14]. The clinical level of attachment does not necessarily correspond with the histologic level of attachment. Automated measurement devices like Florida probe and Toronto probe, which provide simultaneous computer-assisted measurements are expensive they are not ideal for daily routine in the practice [15]. Radiographs are crucial to diagnose periodontal disease. Limitations of 2D image are difficulty to distinguish buccal and lingual cortical plates as they overlap with the tooth structures, proximal defects and furcation involvement may be masked, furthermore, about **30-50**% of bone **loss** is needed for the defect to be visible [15], [16]. Projection geometry, exposure parameters and developmental factors can have an impact on the periodontal hard tissues. CBCT provides three-dimensional images to assess periodontal defects which enables more reliable tooth prognosis and therapeutic planning, but the drawback is lack of visualization of soft periodontal tissues. The simultaneous depiction of gingival tissue morphology (thickness and volume) and pocket imaging would be desirable for functional and aesthetic considerations. In our study we found the CBCT measurements to be comparable with that of clinical probing. This outcome supports the feasibility of this innovative idea to visualize both the soft and hard tissue components of the pocket simplifying diagnosis and therapeutic planning.

Gingival Collar Assessment After Implant Placement

Providing an esthetic restoration in the anterior region of the mouth has been the basis of peri-implant esthetics. An esthetic implant restoration is one that resembles a natural tooth in all respects. Both dental and gingival esthetics together provide a harmonious smile [17]. The clinician must be aware of the parameters related to gingival morphology, form, dimension, characterization, surface texture and color. In Implant practice thickness of keratinised tissue matters for the success of the implant. If the thickness of the tissue is less before placing the gingival former, soft tissue augmentation with free gingival graft is done which helps in getting the desired emergence profile for the final prosthesis [18]. In our study, by using CBCT and barium coated special tray the exact thickness from the implant surface to the fitting surface of the tray was measured. This measurement can be used to select the appropriate thickness of free gingival graft required for soft tissue augmentation.
Limitations of the study –It has limited use in patients with dental crowding, cannot be used in patients with metallic crowns and is technique sensitive.

Conclusion

The correlation between CBCT and physical measurement was high except in places of very thin oral mucosa.CBCT because of its non-invasive nature and minimal radiation exposure can be considered as an alternative method for the measurement of oral mucosal thickness.

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