Open Journal of Medical Imaging, **2012, 2, 76-79**
http://dx.doi.org/10.4236/ojmi.2012.22013 Published Online June 2012 (http://www.SciRP.org/journal/ojmi)

Inter-Occlusal Separation in CBCT Imaging: Rationale and Method

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Received March 14, 2012; revised April 16, 2012; accepted April 25, 2012

ABSTRACT

A major advantage of CBCT is the ability to allow single-step data acquisition that computes all our diagnostic information and substitutes several conventional procedures of record taking. Yet, there are several protocols for CBCT imaging as regards the interocclusal separation, each with a drastic shortcoming. The authors herein propose a protocol that offers acceptable inter-occlusal separation during CBCT imaging using a radiolucent splint that guarantees reproducibility, undisrupted facial form, centric condylar position concurrently with feasibility for occlusal analysis, separation of the maxillary and mandibular teeth and hence digital simulation of the orthodontic treatment.

Keywords: Diagnosis; Diagnostic Imaging; Radiography; Cone-Beam Computed Tomography

1. Manuscript Proper

Cone beam computed tomography (CBCT) imaging and its consequent three-dimensional visualization of craniofacial structures are exponentially gaining ground in the orthodontic and maxillofacial disciplines. Unexpectedly, reviewing the literature showed the absence of an explicit discussion of the inter-occlusal separation at the time of CBCT imaging.

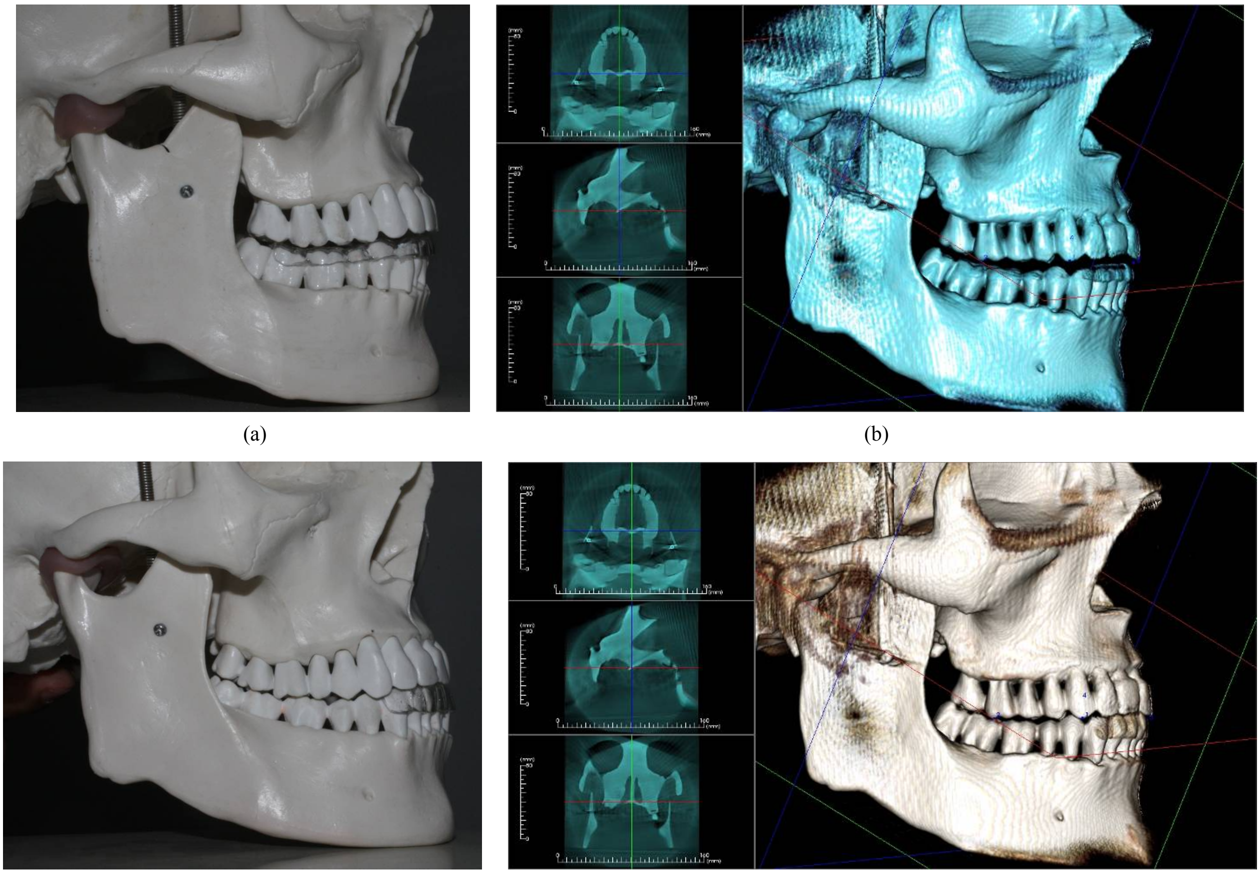
Many articles reporting the use of CBCT did not mention the inter-occlusal separation of the teeth [1-5], but it can be inferred that teeth were in occlusion during imaging. Such imaging protocol, results in a merged or blended occlusal anatomy of the maxillary and mandibular teeth, with subsequent difficulty in separation of the dental arches, occlusal analysis and proper isolation of individual teeth. Another protocol comprises imaging with dental disclusion [6,7]. Although this imaging protocol with an intermaxillary separation permits clear visualization of the occlusal anatomy, yet excessive mandibular opening disrupts the facial form, proportions and relationships. Hence, none of these two protocols satisfy the need for occlusal analysis, and handling of the dentition, with a simultaneous preservation of the facial form.

Concurrently, given a major advantage of CBCT's ability to allow a single-step of data acquisition that computes all our diagnostic information and substitute several conventional procedures of record taking [7], it is irrational to have more than one imaging protocol, each with a drastic shortcoming. A need exists to address the issue of an acceptable inter-occlusal separation during CBCT acquisition that simultaneously guarantees reproducibility, undisrupted facial form, centric condylar position, together with occlusal analysis, separation of the maxillary and mandibular teeth and digital simulation of the orthodontic treatment [8].

Because of the aforementioned reasons, and in addition to the current availability of computer software that permits automatic separation of the maxillary and mandibular teeth with minimal interocclusal separation [8], a new imaging protocol is proposed hereafter.

Othman *et al.* [8] proposed wearing a plastic splint on the entire mandibular dental arch during CBCT imaging. The use of a radiolucent material for intermaxillary separation is a logical premise, but the effect of extending the splint to the second molar during imaging and the associated wedging phenomenon of the mandible on the facial form and proportions was not tested.

Accordingly, we tested the Othman *et al.* technique on a phantom skull as a pilot attempt followed by application on live subjects. The Othman et al splint extending to the second molar was fitted on the mandibular teeth of the phantom skull (**Figure 1(a)**). This results in an increase in vertical dimension at the anterior teeth of 4.5 mm from the position of maximal intercuspation, and a CBCT was taken (**Figure 1(b)**). Then the splint was shortened to end at the distal incline of the lower canine (**Figure 1(c)**). This decreased the vertical dimension at the anterior teeth to 1.28 mm and another CBCT was taken (**Figure 1(d)**). Superimposition of the two CBCT volumes (**Figure 2**) was done to clarify the effect of moving the fulcrum of opening away from the condylar hinge



(a) (b)

(c) (d)

Figure 1. (a) Showing splint extending to the mandibular second molar; (b) Showing CBCT of phantom skull with the splint extending to the mandibular second molar; (c) Showing splint extending to the mandibular canine; (d) Showing CBCT of phantom with the splint extending to the mandibular canine.

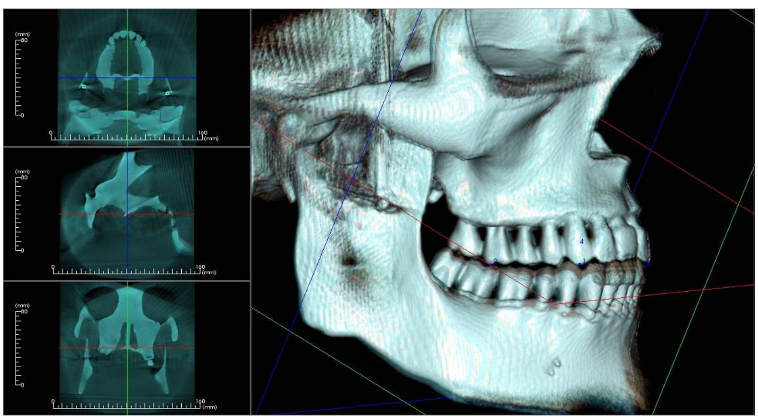


Figure 2. Superimposition of CBCT data (notice the difference in position of mental foramen when the splint is extended to the second molar).

axis upon the anterior separation of teeth (wedging phenomenon of the mandible). This forward relocation of the fulcrum of opening decreases the amount of anterior opening and hence preserves the vertical dimension and facial form.

The same procedure was tried on 15 people having normal occlusion and balanced facial form and proportions; supposedly sensitive to any minute change in the vertical dimension, to find out that a 1 - 1.2 mm of posterior separation (thickness of the splint) at the second molar will result in an average of 4.46 mm anterior separation on average (**Table 1**), with detrimental effect on the

Table 1. Showing the amount of anterior teeth separation accompanying shortening of the splint from the second molar and moving anteriorly until the lower canine.

Most distal contact point of the splint	Distobuccal cusp of lower second molar	Distal cusp tip of lower first molar	Cusp tip of lower second premolar	Cusp tip of lower first premolar	Distal incline of lower canine
Mean amount of anterior teeth separation +/− SD	4.46 mm +/− 0.61	3.99 mm +/− 0.43	3.63 mm +/− 0.50	3.21 mm +/− 0.55	2.0 mm +/− 0.33

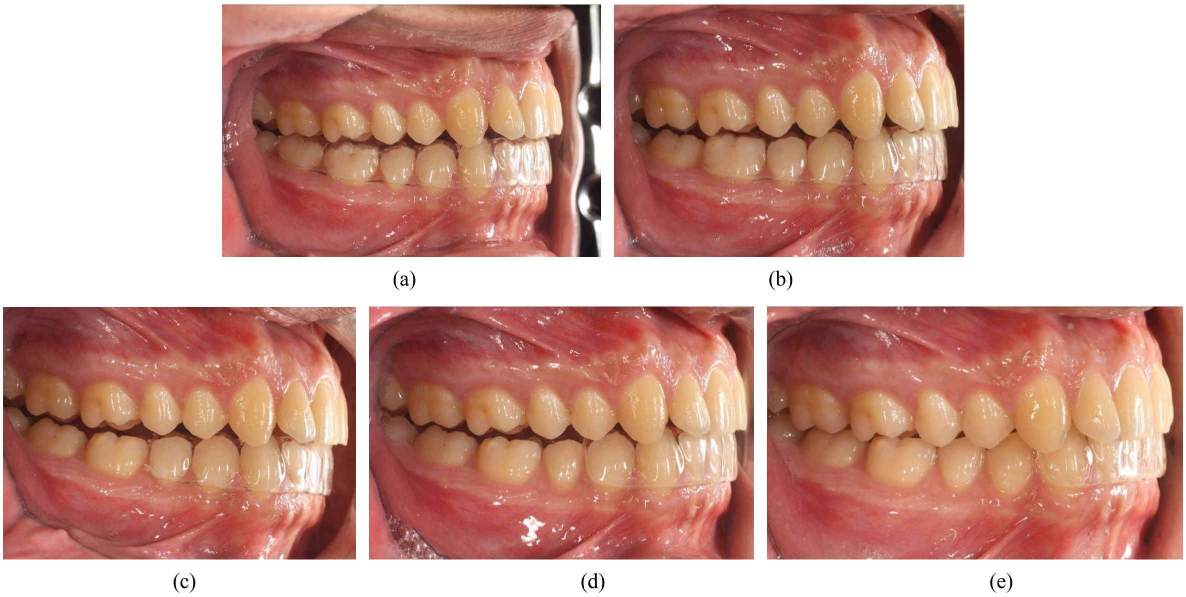


Figure 3. (a) Splint extending to second molar; (b) Splint extending to first molar; (c) Splint extending to second premolar; (d) Splint extending to first premolar; (e) Splint extending to canine.

Figure 4. CBCT of live subject showing the negligible effect of the splint extending to the mandibular canine on the mouth opening.

facial proportions.

Thus, we began shortening of the splint one tooth at a time starting from the second molar and moving anteriorly. This procedure shifted the contact with the maxillary teeth in a forward direction, and the separation in the anterior teeth region decreased consecutively (**Figure 3**). This protocol was continued until the splint ended at the distal incline of the lower canine. This separation of 1 - 1.2 mm at the canine region offered a separation of an average of 2 mm at the midline (**Table 1**). Such amount of anterior opening keeps minimal posterior separation for automatic segmentation of the maxillary and mandibular teeth (**Figure 4**). Furthermore, being within the freeway space, facial form and esthetics are preserved. We elected to end the 1 mm thick splint at the canine region, in order to block the overjet at the corner of the dental arch and hence prevent any lateral eccentric movement of the mandible during imaging.

The numbers in the table indicate that an intermaxillary separation at the second molar is expressed as four fold at the incisor region. Thus, in situations where there is no contact between the maxillary and mandibular dental arches at the canine region; such as some cases of openbite or skeletal class III cases, the splint is fabricated to a thickness of 0.5 mm and is extended to the most distal mandibular molar (second molar or the distal cusp of the first molar) to offer the same intermaxillary separation in the anterior region.

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