ORIGINAL ARTICLE CE AJO-DO

Cone-beam computed tomography transverse analyses. Part 2: Measures of performance

R. Matthew Miner,[a] Salem Al Qabandi,[b] Paul H. Rigali,[c] and Leslie A. Will[d]
Boston, Mass, Salmiya, Kuwait, and Woodstock, VT

Introduction: The aim of this study was to compare the predictability of the cone-beam transverse (CBT), jugale (J-point), and transpalatal width measurement (TWM) analyses in identifying clinical crossbite. **Methods:** From a pool of patients with cone-beam computed tomography scans who came for orthodontic treatment, a sample of 133 patients was identified, with 54 in posterior crossbite (28 boys, 26 girls) and 79 not in crossbite (77 boys, 110 girls). No patient had dental compensation in this sample. After correcting for lateral mandibular shift, 33 of the 54 posterior crossbite patients had a bilateral crossbite, and 21 had a unilateral crossbite with no shift. The CBT, J-point, and TWM analyses were done for each patient from a coronal cross-section through the middle of both the maxillary and mandibular first molar crowns. The landmarks and measurements used were described in detail in a previous study. Posteroanterior cephalograms were constructed to simulate the geometry of the conventional cephalometric radiographs. All 3 analyses were performed on the same data set to predict whether crossbite was present. We used 2 assessments of diagnostic predictability: sensitivity and specificity, and positive and negative predictive values. While the 2 methods answer different questions, the prevalence of crossbite in a population will affect the positive and negative predictive values, but the sensitivity and specificity will not change. **Results:** Of the 133 patients studied, 54 had a clinical crossbite, and 79 had no crossbite. The J-point analysis accurately predicted that 38 patients would have a crossbite, and 45 would not. This resulted in a positive predictive value of 52.78%, a negative predictive value of 73.77%, sensitivity of 70.4%, and specificity of 57%. The TWM analysis accurately predicted that 53 patients would have a crossbite, but it falsely predicted that an additional 68 patients would have crossbite. This resulted in a positive predictive value of 43.8%, a negative predictive value of 91.67%, sensitivity of 98.1%, and specificity of 13.9%. The CBT analysis correctly predicted a crossbite in 47 patients and accurately predicted no crossbite in 73 patients. This resulted in a positive predictive value of 88.68%, a negative predictive value of 91.25%, sensitivity of 87.0%, and specificity of 92.4%. **Conclusions:** This study showed that although the TWM analysis had slightly better negative predictive and sensitivity values, the CBT analysis was overall better at both predictive value and sensitivity/specificity because of the limitations in J-point landmarks and the extent of the TWM analysis. Furthermore, the CBT analysis can distinguish between skeletal and dental discrepancies. Further work will test the analysis on additional samples with differing prevalences of crossbite. (Am J Orthod Dentofacial Orthop 2015;148:253-63)

Posterior crossbite is a common malocclusion occurring in the deciduous and mixed dentitions. It occurs in 1% to 23% of the population in the United States.[1-3] The etiology of crossbite is multifactorial, including congenital, developmental, traumatic, and iatrogenic factors.[4] A common factor is a thumb-sucking habit, where the maxillary arch tends to become V-shaped with greater constrictions at the canine areas.[5]

Posterior crossbite can be unilateral or bilateral and may develop at any time during the eruption of the deciduous or permanent dentition.[6,7] If left untreated, the crossbite can have a long-term effect on the growth and development of the teeth, jaws, and soft tissues of the oral cavity.[2,5,8] Most studies have supported the early diagnosis and treatment of a crossbite to establish an ideal environment for normal growth and development that helps to prevent further malocclusion and minimize the need for comprehensive orthodontic treatment.[1,5,9,10]

[a]Adjunct clinical professor, Department of Orthodontics, Goldman School of Dental Medicine, Boston University, Boston, Mass.
[b]Orthodontist, Bayan Dental Center, Kuwait City, Kuwait.
[c]Adjunct associate professor, Department of Orthodontics, Goldman School of Dental Medicine, Boston University, Boston, Mass; private practice, Woodstock, Vt.
[d]Professor and Anthony A. Gianelly chair, Department of Orthodontics, Goldman School of Dental Medicine, Boston University, Boston, Mass.
All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and none were reported.
Address correspondence to: Leslie A. Will, Goldman School of Dental Medicine, Boston University, 100 E Newton St, Room 104, Boston, MA 02118; e-mail, willla@bu.edu.
Submitted, March 2012; revised and accepted, March 2015.
0889-5406/$36.00

http://dx.doi.org/10.1016/j.ajodo.2015.03.027

A number of posteroanterior cephalometric and cast analyses have evaluated the breadth, symmetry, morphology, shape, and size of the craniofacial skeleton.[11-15] The posteroanterior analysis of Ricketts[4,11] and the maxillary transpalatal width measurement (TWM) developed by Howe et al[15] are among the more widely used analyses in evaluating the transverse dimensions, but these traditional analyses have limitations. The jugale (J-point) analysis relies on accurate identification of the intersection between the contour of the maxillary tuberosity and the inferior border of the zygomatic buttress to determine the width of the maxilla to compare with the mandibular width. With this analysis, superimposition of many structures on the posteroanterior view can reduce the clarity of the landmarks and increase identification errors. In addition, when measuring the J-points, any rotation of the head about a vertical axis when the posteroanterior cephalogram is taken affects the horizontal relationships of 3-dimensional (3D) landmarks, making it hard to assess symmetry and measure horizontal distances.[16] When using the TWM, the distance is measured from the cervical midlingual region between the permanent first molars. This measurement is significantly affected by molar inclination and does not truly represent the maxillary skeletal dimension.[17]

Three-dimensional craniofacial imaging enables orthodontists to appreciate the complexities of 3D craniofacial structures. Using cone-beam computed tomography (CBCT), 3D images of asymmetry, condylar pathology, airway patency, skeletal discrepancies, and dental abnormalities can be visualized clearly and from multiple angles. Most of these images were not possible with standard 2-dimensional radiographs.[18-21]

In a previous study, we developed a cone-beam transverse (CBT) analysis that evaluates the transverse jaw relationships and can aid in differentiating between skeletal and dental transverse problems.[22] A detailed description of the analysis is given in the Appendix.

The aim of this study was to compare the predictability of the CBT, J-point, and TWM analyses in identifying clinical crossbite. Our previous study indicated that the lack of a dental crossbite does not necessarily mean that no transverse discrepancy exists. However, it is difficult to validate norms without a clearly defined standard, and our analysis identifies dental compensation for skeletal discrepancy. Therefore, we chose to test the ability of our analysis to predict clinical dental crossbites with that of the J-point and TWM analyses.

We used 2 assessments of predictability: sensitivity/specificity, and positive and negative predictive values. Each test has advantages and disadvantages, but each is easily calculated using the numbers of true and false positives and negatives after applying the different analyses.

MATERIAL AND METHODS

In our previous study, we examined the records of 2279 orthodontic patients who had a CBCT scan from 2 private orthodontic offices that used an i-CAT Classic scanner (Imaging Sciences International, Hatfield, Pa).[22] This study, examining retrospective records of patients presenting for treatment, was approved by the institutional review board at Harvard University, Cambridge, Mass.

All selected patients were in the mixed or permanent dentition with erupted maxillary and mandibular permanent first molars in bilateral Angle Class I molar relationships, with the mesiobuccal cusp within 1 mm of the buccal groove of the mandibular first molar. The entire crossbite sample had a lingual crossbite between the maxillary and mandibular permanent first molars on at least 1 side. We excluded patients with missing teeth (other than third molars), crowding of more than 4 mm, overbite or overjet of more than 4 mm, crowns or cuspal restorations, previous orthodontic treatment, and histories of craniofacial trauma, surgery, or temporomandibular joint symptoms.

Our preliminary sample included 241 patients, of whom 54 had posterior crossbite (28 boys, 26 girls) and 187 were without crossbite (77 boys, 110 girls). From these 187 patients, 79 (34 boys, 45 girls) also had no dental compensation as determined from our previous study.[22] These 79 were designated as the control group. Patients who were previously identified as having no crossbites but had dental compensations (n = 108) were excluded from this study to more clearly identify patients with a clinical crossbite. All CBCT scans were taken in centric relation as determined by the treating orthodontist after correcting for mandibular shifts. Thirty-three of the 54 posterior crossbite patients had a bilateral crossbite, and 21 had a unilateral crossbite with no shift. Our final study group had 54 patients with crossbite and 79 control patients, for a total of 133 patients.

First, the CBCT scan for each patient was exported in a DICOM3 format and imported into cephalometric analysis software (version 10.5; Dolphin Imaging & Management Solutions, Chatsworth, Calif). The 3D reconstructed volume was oriented with the Frankfort horizontal plane parallel to the floor. Posteroanterior cephalograms were constructed using the perspective reconstruction algorithm of the analysis software with 10% magnification of the midsagittal plane, thus simulating the geometry of the conventional cephalometric radiograph.