Novel 3-dimensional analysis to evaluate temporomandibular joint space and shape

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Introduction: The purpose of this study was to present and validate a novel semiautomated method for 3-dimensional evaluation of the temporomandibular joint (TMJ) space and condylar and articular shapes using cone-beam computed tomographic data. **Methods:** The protocol for 3-dimensional analysis with the Checkpoint software (Stratovan, Davis, Calif) was established by analyzing cone-beam computed tomographic images of 14 TMJs representing a range of TMJ shape variations. Upon establishment of the novel method, analysis of 5 TMJs was further repeated by several investigators to assess the reliability of the analysis. **Results:** Principal components analysis identified 3 key components that characterized how the condylar head shape varied among the 14 TMJs. Principal component analysis allowed determination of the minimum number of landmarks or patch density to define the shape variability in this sample. Average errors of landmark placement ranged from 1.15% to 3.65%, and none of the 121 landmarks showed significant average errors equal to or greater than 5%. Thus, the mean intraobserver difference was small and within the clinically accepted margin of error. Interobserver error was not significantly greater than intraobserver error, indicating that this is a reliable methodology. **Conclusions:** This novel semiautomatic method is a reliable tool for the 3-dimensional analysis of the TMJ including both the form and the space between the articular eminence and the condylar head. (Am J Orthod Dentofacial Orthop 2016;149:416-28)

Conventional 2-dimensional radiographs have major drawbacks in the assessment of condylar position and morphology because of overlapping anatomic structures and inherent distortion in 2-dimensional imaging of a 3-dimensional (3D) structure, as well as magnification errors.[1,2] Furthermore, with conventional radiography and tomography, it is difficult to reproduce the x-ray beam projection for follow-up radiography; this is crucial for long-term evaluation of the temporomandibular joint (TMJ).[3] Condylar position changes should be analyzed in 3 dimensions; to achieve this with conventional radiographs, multiple views are required, such as combining submentovertex radiographs and axially corrected sagittal and coronal tomography.[4,5] Computed tomography provides far superior imaging of the hard tissues of the TMJ, and 1 imaging sequence provides the necessary information, but the increased radiation exposure and high cost have limited its application.[6,7] Although magnetic resonance imaging provides images of both soft and hard tissues without exposing patients to radiation, high cost and a long scanning time makes it less accessible.[7]

Cone-beam computed tomography (CBCT) has overcome many shortcomings of the aforementioned imaging techniques. Hilgers et al[8] found that CBCT images are highly accurate compared with direct anatomic measurements, whereas measurements made with conventional radiographs are significantly greater than the

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Checkpoint software, used in this study, was developed by Stratovan (Davis, Calif); David Wiley and Christian Woodhouse are employees in that corporation. No other conflicts of interest were reported.
This is a New York Consortium in Evolutionary Primatology (NYCEP) morphometrics group contribution 95.
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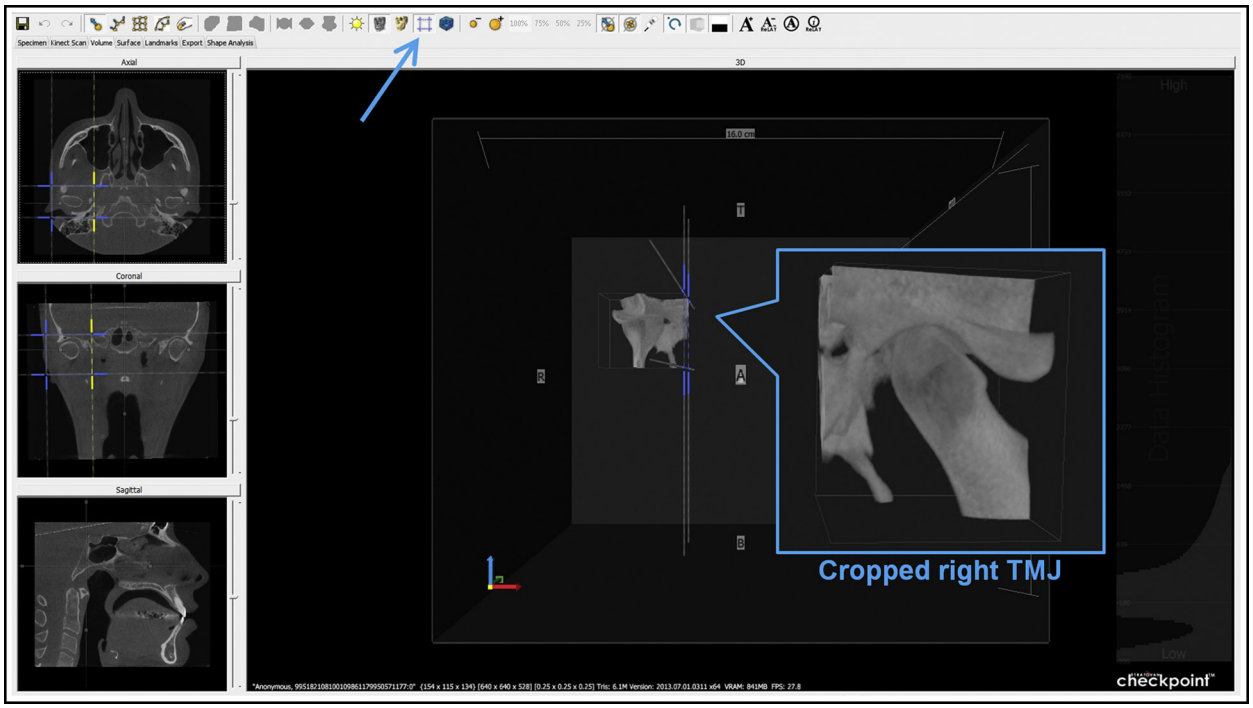

Fig 1. Cropped volume isolating the right condyle-fossa unit.

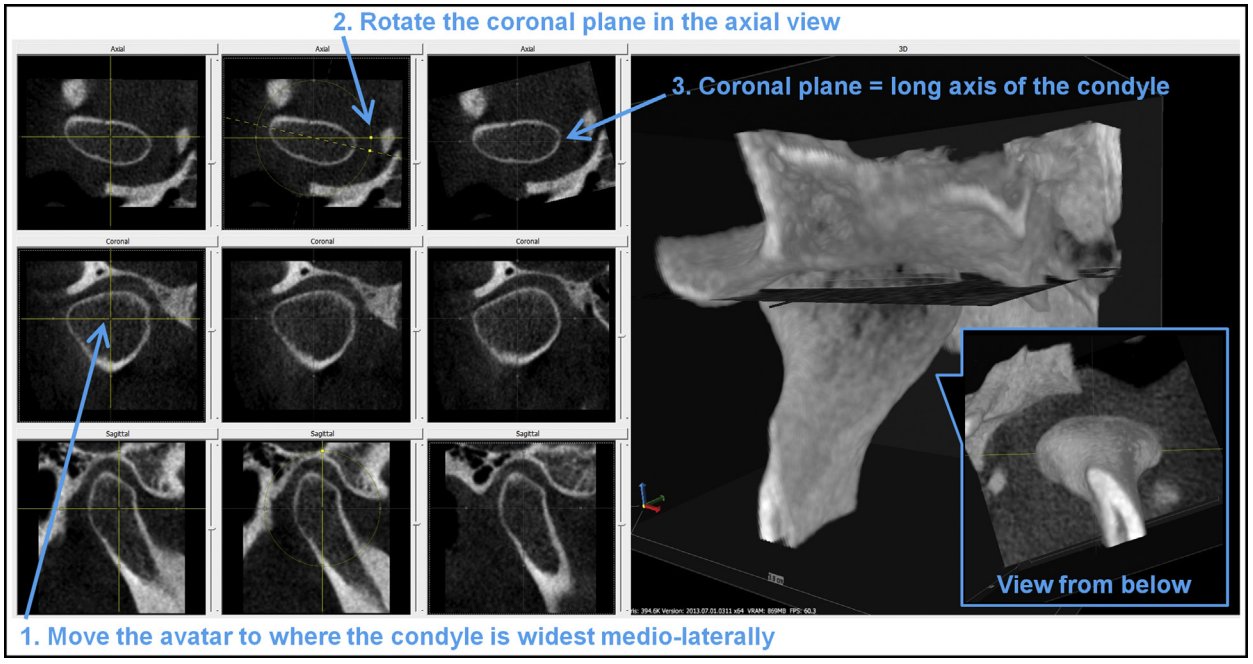

Fig 2. Oriented TMJ along the long axis of the condyle.