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Research

Comprehensive three-dimensional cone beam computed tomography analysis of the temporomandibular joint in different vertical skeletal facial patterns

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ABSTRACT

Background: To investigate three-dimensionally using cone beam computed tomography (CBCT) imaging the morphological and spatial characteristics of the temporomandibular joints (TMJs) in different vertical skeletal facial patterns.
Materials and Methods: Sixty adult patients with no signs and symptoms of temporomandibular disorders were divided equally into three groups: skeletal normal vertical face, long face, and short face malocclusions. Bilateral TMJs were evaluated on the CBCT images, and the following three-dimensional measurements were assessed: (1) mandibular fossa position, inclination, and parameters, (2) mandibular condyle position, inclination, and parameters, and (3) circumferential TMJ space measurements.
Results: The average mandibular plane inclination was 32.77 ± 1.17° for average pattern, 48.33 ± 2.76° for long face, and 27.27 ± 2.30° for short face malocclusion. Long face showed the statistically significant highest glenoid fossa width (18.34 ± 2.20 mm), more lateral positioned condyles, and more anterioposterior condylar joint position. The long face pattern showed the highest mean value of medial joint space. The short face pattern showed the highest glenoid fossa surface area (106.40 ± 14.68 mm^2), sagittal condylar surface area (48.47 ± 4.54 mm^2), and superior and anterior joint spaces, as well as lowest posterior joint spaces.
Conclusion: The TMJ parameters differ between different vertical facial patterns that should be considered when planning an orthodontic case.

1. Introduction

Functional loads applied to the temporomandibular joint (TMJ) might influence its morphology. Loads on the TMJ could vary according to the subjects' dentofacial morphologies. Therefore, it could be suggested that both the condyle and the mandibular fossa differ in shape in subjects with various dentofacial patterns. The influence of occlusion on joint morphology is still not completely understood; some studies suggested the existence of direct relation [1–3], while others failed to find any correlations [4]. Part of this controversy is due to the difference in the evaluation techniques at the time of study and the use of subjective scoring system rather than standardized methods for analyzing this complex region [5].

As the relationship of the mandible to the cranial base influences both sagittal and vertical facial disharmonies, the TMJ is likely to play an important role in the establishment of different craniofacial patterns. The literature provides only limited data about the diagnostic significance of the position of the glenoid fossa in different skeletal vertical pattern [6], and, so far, no study in the literature assessed the different parameters and position of different components of the TMJ in relation to other skeletal vertical structures.

Maxillofacial cone beam computed tomography (CBCT) could provide submillimeter spatial resolution images with markedly shorter scanning times and has been reported to require somewhat lower radiation dosages than computed tomography (CT) imaging methods. Most of the studies that assessed the configuration of the TMJ in different anterioposterior skeletal pattern used low-dose, less-accurate lateral cephalometry [7] or tomography [8–10] or high-dose, more-accurate computed tomography

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Table 1
Definitions of general and TMJ anatomical landmarks for three-dimensional cone beam computed tomography analysis (Figs. 1 and 2)

No	Landmark	Definition
1	Nasion (N)	Nasofrontal structure in the midline.
2	Sella (S)	Center of the pituitary fossa in the middle cranial fossa.
3	Right/orbitale (Or)	The right or left most inferior point on the infraorbital rim of the maxilla.
4	Left porion (PO)	The left most outer and superior bony point of the external acoustic meatus.
5	Right/left gonion (Go)	The right or left midpoint on the angle of the mandible, halfway between the corpus and ramus.
6	Anterior nasal spine (ANS)	The most anterior and midpoint of the anterior nasal spine of the maxilla.
7	Posterior nasal spine (PNS)	The most posterior midpoint of the posterior nasal spine of the palatine bone.
8	Subspinale (A)	The deepest point of the middle of the maxillary frontal surface.
9	Supramentale (B)	The deepest point of the middle mandibular frontal surface.
10	Menton (Me)	The most inferior midpoint of the chin on the outline of the MD symphysis.
11	Gnathion (Gn)	The most inferior and anterior midpoint of the chin on the outline of the MD symphysis.
12	Soft tissue mandibular fossa (MFS)	The most superior and midpoint of the soft tissue right or left mandibular fossa region.
13	Bony mandibular fossa (MF)	The most superior and midpoint of the bony right or left mandibular fossa.
14	Medial joint space “fossa point” (MJSf)	The most right or left lateral point of the medial wall of mandibular fossa.
15	Superior condylar point (SCP)	The most right or left superior point of the condylar head.
16	Lateral condylar point (LCP)	The most right or left lateral point of the condylar head.
17	Medial condylar point (MCP)	The most right or left medial point of the condylar head.
18	Geometric condylar center (GC)	The center of the right or left condyle.
19	Anterior condylar point (ACP)	The most right or left anterior point of the condylar head.
20	Posterior condylar point (PCP)	The most right or left posterior point of the condylar head.
21	Condylar width “anterior point” (CWa)	The most anterior point of the right or left condyle corresponding to the area of maximum width.
22	Condylar width “posterior point” (CWp)	The most posterior point of the right or left condyle corresponding to the area of maximum width.
23	Articular tubercle (AT)	The most inferior and posterior point of right or left articular tubercle.
24	Inferior meatus (IM)	The most inferior and lateral point of right or left external auditory meatus.
25	Anterior fossa point (AF)	The most anterior and inferior point in the right or left anterior wall of the mandibular fossa.
26	Posterior fossa point (PF)	The most posterior and inferior point in the right or left posterior wall of the mandibular fossa opposed to IM point.
27	Anterior neck point (ANP)	The deepest anterior point of right or left mandibular condylar neck.
28	Posterior neck point (PNP)	The most posterior point of right or left mandibular condylar neck.
29	Anterior fossa inclination “superior point” (AFIs)	The right or left superior point of a line tangent to the most posterior mandibular fossa area opposing to anterior condylar area.
30	Anterior fossa inclination “inferior point” (AFIi)	The right or left inferior point of a line tangent to the most posterior mandibular fossa area opposing to anterior condylar area.
31	Posterior fossa inclination “superior point” (PFIs)	The right or left superior point of a line tangent to the most anterior mandibular fossa area opposing to posterior condylar area.
32	Posterior fossa inclination “inferior point” (PFIi)	The right or left inferior point of a line tangent to the most anterior mandibular fossa area opposing to posterior condylar area.
33	Anterior joint space “fossa point” (AJSf)	The most posterior point of the right or left anterior wall of the mandibular fossa opposed to the shortest anterior condylar-fossa distance.
34	Anterior joint space “condylar point” (AJSc)	The most anterior point of the right or left condyle opposed to the shortest anterior condylar-fossa distance.
35	Posterior joint space “fossa point” (PJSf)	The most anterior point of the right or left posterior wall of the mandibular fossa opposed to the shortest posterior condylar-fossa distance.
36	Posterior joint space “condylar point” (PJSc)	The most posterior point of the right or left condyle opposed to the shortest posterior condylar-fossa distance.

(Reproduced and modified with permission from Alhammadi et al. [13].)

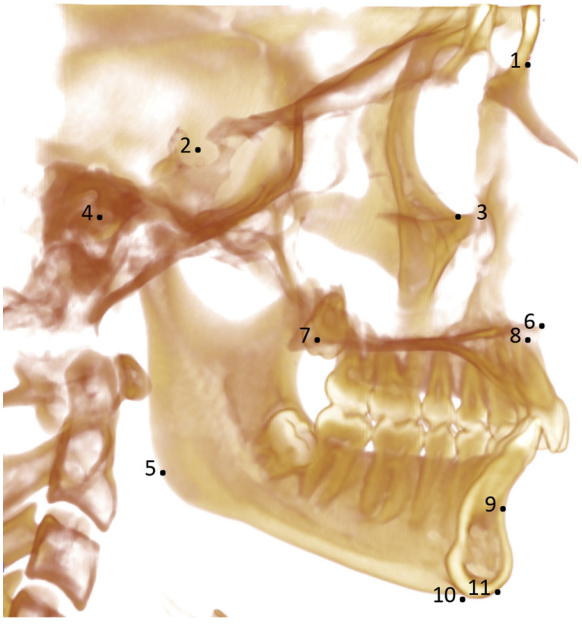

Fig. 1. General anatomical landmarks for 3D cone beam computed tomography analysis. (Reproduced and modified with permission from Alhammadi et al. [13].)

[4,11], but the use of CBCT in assessment of this area in different faces types is still limited.

The methodology and analysis also play an important role in the consistency of measurements in this complex region. The most common methods used in the literature regarding this issue are that of Vitral et al. [4] for computed tomography and the CBCT analysis that were proposed by Arieta-Miranda et al. [12]. Although both methods used three-dimensional (3D) imaging modality, none of them were based on 3D determination of each identified landmark.

The aims of this study was to investigate three-dimensionally using low-dose, highly accurate CBCT imaging morphological and spatial characteristics of the TMJs in different vertical skeletal malocclusions using recently innovative analyses described by Alhammadi et al. [13] including inclination, position of every TMJ component in the three orthogonal planes, as well as TMJ parameters including length, width, height, and surface area.

2. Materials and methods

This study approved by The Research Ethics Committee, Faculty of Oral and Dental Medicine, Cairo University, Egypt. Sample size calculated to determine the minimum required study sample. A power analysis of anterior and superior joint space data was designed considering a mean difference of 0.5 mm in anterior joint