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Comparison of the Condyle-Fossa Relationship and Resorption Between Patients With and Without Juvenile Idiopathic Arthritis (JIA): A Retrospective Three-Dimensional Cone-Beam Computed Tomography Study

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COMPARISON OF THE CONDYLE-FOSSA RELATIONSHIP AND RESORPTION BETWEEN PATIENTS WITH AND WITHOUT JUVENILE IDIOPATHIC ARTHRITIS (JIA): A RETROSPECTIVE THREE-DIMENSIONAL CONE-BEAM COMPUTED TOMOGRAPHY STUDY

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ORTHODONTICS

ABSTRACT

Introduction: The most common disease in pediatric rheumatology is juvenile idiopathic arthritis (JIA). JIA is considered to be an autoimmune disease with an onset before the age of 16. The temporal mandibular joint (TMJ) has been reported to be involved in up to 87% of patients with JIA. Even though much research has been conducted on JIA, limited research has studied to understand its effect on the condyle-fossa relationship and to evaluate resorption amount on condyle by using a scoring system.

Aim: The purpose of this study was (1) to evaluate the anatomical features of the glenoid fossa, (2) to assess the anatomical features of the condylar head, (3) to evaluate the space between glenoid fossa and the condylar head.

Methods: The present retrospective cross-sectional study included Cone Beam CT (CBCT) images obtained from the sagittal, coronal, and axial slices. In the multidisciplinary Pediatric Rheumatology Outpatient Clinic at The University of Alabama at Birmingham (UAB) children with JIA are also examined by a group of orthodontists working in the same institute from October 2018 to July 2019. The predictor variable consists of patients with JIA and without JIA. The primary outcome variables are the depth of the mandibular fossa, joint spaces, axial angles, medio-lateral width, and condyle resorption. Other study variables were age and sex. In this study, the measurements obtained from two different groups (with JIA and without JIA) are compared using a t-test, where Tukey is utilized to adjust for multiple comparisons. The left and right joints are analyzed separately as the paired t-test conducted showed a significant difference between the two joints ($p < 0.05$).

Results: The study was comprised of 34 patients diagnosed with JIA and 34 healthy subjects. The depth of the mandibular fossa, the anterior joint spaces, the axial angles, and the resorption index showed statistically significant differences between the JIA and healthy groups in both left and right sides ($P<.05$). However, there was no statistically significant difference in the posterior joint spaces and mediolateral width between JIA and healthy groups in both sides ($P>.05$).

Conclusions: The results of our study presented the destructive potential of juvenile idiopathic arthritis by using CBCT. CBCT scanning is a helpful tool in the evaluation of the radiographic result of TMJ .

Keywords: Juvenile idiopathic arthritis, temporal mandibular joint, Cone Beam CT, condyle-fossa relationship

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INTRODUCTION

The most common disease in pediatric rheumatology is juvenile idiopathic arthritis (JIA).[1] JIA is considered to be an autoimmune disease with an onset before the age of 16 that is characterized by chronic inflammation of one or more joints with a minimum duration of 6 weeks.[2,3] Chronic inflammation leads to progressive destruction of the affected joint. The temporal mandibular joint (TMJ) has been reported to be involved in up to 87% of patients with JIA.[1,4] However, it continues to be one of the most underdiagnosed and undertreated conditions due to the difficulties in diagnosing using clinical parameters or imaging techniques.[4,5] Even when there is TMJ involvement, 69% of affected patients are asymptomatic.[4]

Diagnosis

Clinical symptoms are not reliable in detection of TMJ involvement in children with JIA, because neither pain nor swelling is present in the majority of cases. In a study of 97 children with JIA,[6] only 12% complained of pain and 5% had swelling. Among those with pain, only half had evidence of TMJ arthritis on OPG. Other studies have shown similar results, suggesting that clinical symptoms are neither sensitive nor specific in detection of TMJ arthritis.[7,8]

The current "gold standard" imaging technique for diagnosing TMJ arthritis is contrast-enhanced magnetic resonance imaging (MRI), which is expensive.[1] Other imaging modalities such as x-ray, computed tomography (CT), and high-resolution ultrasound (US) do not provide the necessary sensitivity to diagnose TMJ disease or offer a concerning dose to pediatric patients.[4] Cone-beam computed tomography (CBCT) imaging has proven to be a cost and dose effective imaging modality that is accurate and superior in TMJ assessment in comparison to conventional radiographic exams.[9-11] It is important to note that CBCT scans cannot evaluate soft tissue abnormalities or detect acute inflammation.[12] CBCT scans can only reveal changes to the TMJ following chronic inflammation.

The high probability of TMJ arthritic progression can lead to many TMJ abnormalities.[10] JIA patients have shown both unilateral and bilateral condylar destruction during early and late courses of the disease which can lead to condylar asymmetry, malocclusions, masticatory dysfunction, or disturbance of the intra-articular disk.[10] Since JIA patients are at higher risk for developing TMJ abnormalities that can produce long term disability, it is important to develop clinical or imaging parameters that can be used to diagnose these irregularities early on to allow for treatment.[4]

Findings on TMJ examination in children with JIA include decreased mouth opening, clicking or crepitation, tenderness to palpation, asymmetric opening, and absence of translation (forward movement of the jaw upon maximal opening). Studies evaluating maximal mouth opening in normal subjects versus those with periodontal or TMJ disease have shown that failure to open 3.5–4.0 cm (interincisor distance) or more is indicative of a restraining effect on mandibular function warranting further investigation.[13] Ingervall[14] established normal maximal incisal opening ranges at 7, 10, and 20 years of age. Larger studies of patients with JIA have confirmed this finding albeit in a lower percentage of children, mainly those with severe or prcolonged TMJ arthritis.[6,7] Similarly, clicking, crepitation, asymmetric opening, and absence of translation have been shown to be important predictors of TMJ arthritis with good specificity but low sensitivity.[6]

JIA is subdivided into categories that are based on the number of joints affected and the presence or absence of specific serologic findings and systemic manifestations. In contrast to adult-onset rheumatoid arthritis affecting small joints in the hands and feet, JIA predominantly involves the large joints— most frequently the knees, wrists, and ankles. Localized growth disturbances, bone fusion, atlantoaxial subluxation in the cervical spine, and mandibular underdevelopment (ie, micrognathia) are characteristic features.[15]

Ultrasound is an attractive alternative to MRI given that it is safe, noninvasive, and can be easily performed at bedside, particularly for follow-up of disease activity or assessment of treatment response. Evaluation of ultrasound in other joints has shown that it is quite sensitive in making the distinction between effusion and synovial hypertrophy, allowing identification of acute joint inflammation.[16] Several recent studies have evaluated the diagnostic quality of TMJ ultrasound, using MRI as a reference.[17] In 100 patients with TMJ disorders (200 TMJs), high-resolution ultrasound yielded a sensitivity of 81%, a specificity of 100%, and accuracy of 95% in detection of effusion.[18]

Incidence and prevalence

The reported prevalence of TMJ arthritis has varied widely, between 17 and 87%, based on subtype of JIA, methods used for diagnosis, and population studied.[19] In one of the largest studies evaluating TMJ involvement in children with JIA, 62% of 169 patients exhibited condylar resorption on orthopantomogram (OPG).[19] The worst outcomes are reported in patients with systemic or polyarticular disease, young age at disease onset, or an extended disease course. Among this subgroup of patients, those with a positive antinuclear antibody titer have a higher prevalence of condylar resorption.[20,21]

Treatment

Due to the relatively delayed diagnosis of TMJ arthritis in most children with JIA, treatment has most often been directed toward correction of malocclusion, micrognathia, and dysfunction in severely affected patients. These treatments have included functional appliances such as distraction splints or bimaxillary activators or surgery such as vertical ramus elongation by distraction osteogenesis.[22] Although favorable cosmetic and functional outcomes have been obtained with surgery, it is associated with increased morbidity, including a 62% incidence of neurosensory dysfunction and 20% of patients requiring reoperation.[23] Until recently, little attention has been paid to early diagnosis and prevention of inflammatory damage to the growing jaw and TMJ. Nonsteroidal anti-inflammatory drugs and methotrexate have been tried with varying success in treating TMJ arthritis.[24] Ince et al.[25] published one of the only studies to evaluate the efficacy of methotrexate therapy in minimizing TMJ destruction and cranifacial dysmorphology in patients with JRA. Arthrocentesis, with or without injection of sodium hyaluronate, has been used in adults with TMJ osteoarthritis, but no data are available for its use in JIA.[26] A recent promising therapeutic intervention for treatment of TMJ arthritis in JIA is intra-articular corticosteroid injection. Previously, intra-articular corticosteroids were proven beneficial in prevention of leg-length discrepancy in children with oligoarthritis of the knee.[27] By inference, their use in TMJ arthritis can potentially prevent mandibular growth alterations, which lead to micrognathia and jaw deviation. Until recently, there were very few studies of TMJ corticosteroid injection in JIA.[28] Horten[29] first reported this procedure in 1953, but many pediatric rheumatologists have been reluctant to recommend it based on reports of steroidinduced chondrolysis in adults with osteoarthritis of the TMJ.[30] By contrast, a recent study of 30 children with JIA who underwent CT-guided TMJ corticosteroid injection showed a very favorable response, with more than half the patients experiencing significant improvement in jaw opening and pain.[8] On follow-up MRI studies on 20 of these patients, 55% had resolution of effusion or synovial enhancement, and only two showed mild progression in condylar erosion. Of note, 65% of these patients had already been maintained on methotrexate and 20% were also on TNF inhibitors, and the improvement in their TMJ arthritis was seen only after intra-articular corticosteroid injection.[8]

The temporomandibular joint

The temporomandibular joint (TMJ) provides the articulation between the mandible and the temporal bone of the skull. It is a bilateral articulation in that the right and left sides work as a unit. The TMJ has three articulating parts: (1) capitulum of the mandibular condyle; (2) the mandibular fossa and articular eminence of the temporal bone; and (3) the articular disc. A fibrous connective tissue capsule, which supplies synovial fluid for joint lubrication and nourishment, encloses these parts.[31]

The mandibular condyle, also known as the condylar process, is located on the posterior border of the vertical portion of the mandible, also known as the ramus, and forms the articulating surface of the mandible. The condyle is divided into an inferior part called the neck (collum) and a superior or articular part (capitulum). The shape of the condyle is highly variable and may appear irregular radiographically with many of these irregularities. in the bony contour are covered by a thick layer of fibrocartilage. The condylar head appears strongly convex when viewed laterally, but when viewed from the posterior, it exhibits a much wider oblong shape. The superior aspect of the condyle is convex and fits into the mandibular fossa of the temporal bone.[32]

The mandibular fossa is an elliptical depression in the temporal bone positioned anterior to the external auditory canal. Its shape is concave and conforms to the superior portion of the mandibular condyle. The fossa is considered to be a nonfunctioning part of the TMJ due to the fact that when the teeth are in centric occlusion there is no coinciding locked position between the mandibular condyle, the disc, and the concave section of the fossa.[33] The articular eminence is a ridge of bone that borders the anterior limit of the mandibular fossa. The fact that the surface of the articular eminence is covered with a thicker layer of fibrous connective tissue than in the fossa indicates that the eminence is the functional region of the temporal bone during jaw articulation.[34]

The articular disc (meniscus) is located between the articular eminence and mandibular fossa of the temporal bone and the condyle of the mandible. The main functions of the disc are to dampen loading spikes and reduce sliding friction.[35] It consists mainly of dense fibrous tissue and is separated into three regions: the pars anterior, pars intermedia, and pars posterior. The disc is thinner in the pars intermedia and widens at the anterior and posterior ends. The upper surface of the disc is concave anteroposteriorly and convex mediolaterally, conforming to the shape of the articular eminence against which it rests.

The lower surface of the disc is concave in both directions, fitting to the geometry of the condylar head and attaches to the medial and lateral poles of the condylar process by transversely aligned collagen fibers from the pars anterior and pars posterior. Posteriorly the disc continues as a thick double layer of connective tissue termed the bilaminar zone. The main function of the bilaminar zone is to aid in the stability of the disc throughout joint motion. The upper layer of the bilaminar zone attaches to the post glenoid process and the anterior wall of the cartilage forming the external auditory meatus. The lower layer attaches to the posterior portion of the condylar process directly below the articulating part of the condyle. [31]

The ligaments involved in the temporomandibular joint have three main functions: stabilization, guidance of movement, and limitation of movement. The temporomandibular, stylomandibular, and sphenomandibular ligaments are the three primary ligaments of the TMJ. The temporomandibular ligament is the strong reinforcement of the lateral wall of the joint capsule. The fibers of the temporomandibular ligament pass in an inferior and posterior direction from the lateral part of the articular eminence to the posterior portion of the collum of the mandibular condyle. This ligament limits the motion of jaw opening and retrusion. The stylomandibular ligament runs from the styloid process of the temporal bone to the gonial angle of the mandible. Opposed to the temporomandibular joint, it is relaxed during jaw opening and limits protrusive and mediotrusive movements. The sphenomandibular ligament originates in the spine of the sphenoid bone and petrotympanic fissures and runs to the lingula of the mandible. Like the stylomandibular ligament, it limits protrusive and mediotrusive movements.[32]

The primary muscles concerned with closing mandibular motion are the temporalis, masseter, and medial pterygoid. The temporalis is a flat, fan-shaped muscle that originates in the temporal fossa and inserts on the coroniod process and the anterior edge of the ramus of the mandible. It functions as if composed of three distinct parts. The muscle fibers of the anterior part pull upward and serve as elevators. The medial section of the muscle effects jaw closure, with retrusion being a lesser function. The posterior part is involved mainly in retrusion. The masseter is an elevator muscle providing much of the power required for crushing food. It also assists in protrusion. The origin of the masseter muscle arises on the zygomatic arch, and its insertion occurs over the area of the gonial angle of the mandible extending both anteriorly and up the lateral aspect of the ascending ramus. The medial pterygoid muscle originates from the medial surface of the pterygoid plate of the sphenoid bone. Its muscle fibers run in the same direction as those of the masseter muscle, extending downward and laterally on the inner surface of the mandibular ramus and insert on the medial surface of the mandible just superior to the gonial angle. In addition to functioning as an elevator of the mandible, the medial pterygoid aids in lateral positioning and is active during protrusion. Opening motion of the temporomandibular joint is carried out by the lateral pterygoid and suprahyoid musculature. The lateral pterygoid muscle has two sites of origin. Its lower head arises from the outer surface of the lateral pterygoid plate, and the upper head arises from the greater wing of the sphenoid bone. Both heads of the muscle insert on the anterior neck of the condyle and on the joint capsule. The upper and lower head of the lateral pterygoid muscle display an antagonistic relationship. The upper head is active during jaw closing, retrusive, and laterotrusive movements, and the lower head is active during jaw opening, protrusive, and mediotrusive movements. The suprahyoid musculature consists mainly of the digastric, mylohyoid, and geniohyoid muscles. The digastric muscle has two bellies. The posterior belly of the muscle originates medial to the mastoid process, and its fibers extend anteriorly, inferiorly, and medially to the hyoid bone. At the hyoid bone the posterior belly attaches to the anterior belly by means of an intermediate tendon. The anterior belly originates from the inner side of the mandible at the digastric fossa. The mylohyoid muscle stretches from the body of the hyoid bone to the mylohyoid line on the inner side of the corpus of the mandible. The geniohyoid muscle arises from the inferior mental spine on the posterior surface of the symphysis menti of the mandible. It extends as a narrow strap, passing posteriorly and inferiorly to insert into the medial and superior section of the body of the hyoid bone.[32]

HYPOTHESIS AND SPECIFIC AIMS

The hypothesis is that there is no difference in anatomical morphology of the TMJ region in patients with and without JIA.

For this hypothesis we will use the following specific aims:

Specific Aim 1: to evaluate the anatomical features of the glenoid fossa,

Specific Aim 2: to assess the anatomical features of the condylar head,

Specific Aim 3: to evaluate the space between glenoid fossa and the condylar head.

Based on our literature search (Medline, PubMed and Web of Science), we found that the anatomical features of TMJ region (glenoid fossa, space between glenoid fossa and condylar head, and condylar head) has not yet been reported in JIA patients. This study is going to be first study to demonstrate anatomical features of TMJ region in patients with JIA.

MATERIALS AND METHODS

The present retrospective cross-sectional study was performed on patients with JIA and healthy control group were enrolled between July 2016 and December 2018. In the multidisciplinary Pediatric Rheumatology Outpatient Clinic at The University of Alabama at Birmingham (UAB) children with JIA are also examined by a group of orthodontists working in the same institute. These patients attended the Orthodontic Department for a comprehensive dental examination where Cone Beam CT images were obtained as part of the clinical evaluation.

Patients with any of the following characteristics were excluded: (1) congenital syndromes; (2) craniofacial trauma; and (3) previous orthognathic surgery.

The control group had Class I molar and canine relationships with minor crowding enrolled for general orthodontic treatment at the Department of Orthodontics. Only patients who had a CBCT image with a TMJ field of view in their diagnostic records were included. Excluded from the study were patients with (1) having previous or current diagnosis of temporomandibular dysfunction; (2) history of arthritis, immune disease, or systemic disease confirmed by a rheumatologist, or patients under investigation for these diseases; (3) congenital syndrome; (4) craniofacial trauma; and (5) previous orthognathic surgery.

Full ethical approval was obtained from University of Alabama at Birmingham Institutional Review Board (IRB-300000795).

The following data were recorded; age, sex, whether under medication or not, and radiographic evidence.

The CBCT images were acquired by the Carestream 9300 (Atlanta, Georgia) CBCT device which has a scan time of images was 14 seconds, and radiation dosage of about 29 μSi. The voxel size was 0.15–0.30 mm and the greyscale was 12 bit. The CBCT images were reoriented with the horizontal reference plane connecting the bilateral orbitales and Frankfurt horizontal (FH) plane as previously reported.[36] The vertical midline and horizontal reference planes were set accordingly. Data obtained from CBCT were exported in the Digital Imaging and Communications in Medicine (DICOM) format.

Dolphin 3D program (version 11.8; Dolphin Imaging & Management Solutions, Chatsworth, GA, USA) was used for the evaluations of sagittal and coronal images. Firstly, coronal and sagittal planes were adjusted for standardization of all radiographs. The sagittal plane was oriented to reflect the midsagittal plane as bisecting symmetric midfacial structures. The coronal plane was set up by using the transporionic line. After the orientation, all radiographs were saved.

The slice thickness was adjusted to 1 mm and the slice width was fixed to 60 mm with 18 cuts. Sagittal and coronal direction settings were applied, respectfully, in order to detect the largest and most noticeable condyle images. KDIS3D program (Kodak Dental Imaging Software 3Dmodule, v. 2.1.11; Carestream Health Inc., Rochester, NY) was used for evaluations of axial images.

Parameters Measured

The methodology we used to measure sagittal distances and axial angle was described by Vitral et al[37] and Vitral and Telles[38] and coronal distance was defined by

Gorucu-Coskuner et al.[39] Linear measurements of optimal joint space between the condyle and fossa were made on the coronal and sagittal CBCT images by using the landmarks and variables defined as follows:

Depth of the mandibular fossa (Sag Depth): measured from the most superior point of the fossa to the plane formed by the most inferior point of the articular tubercle to the most inferior point of the auditorymeatus (Fig 1).

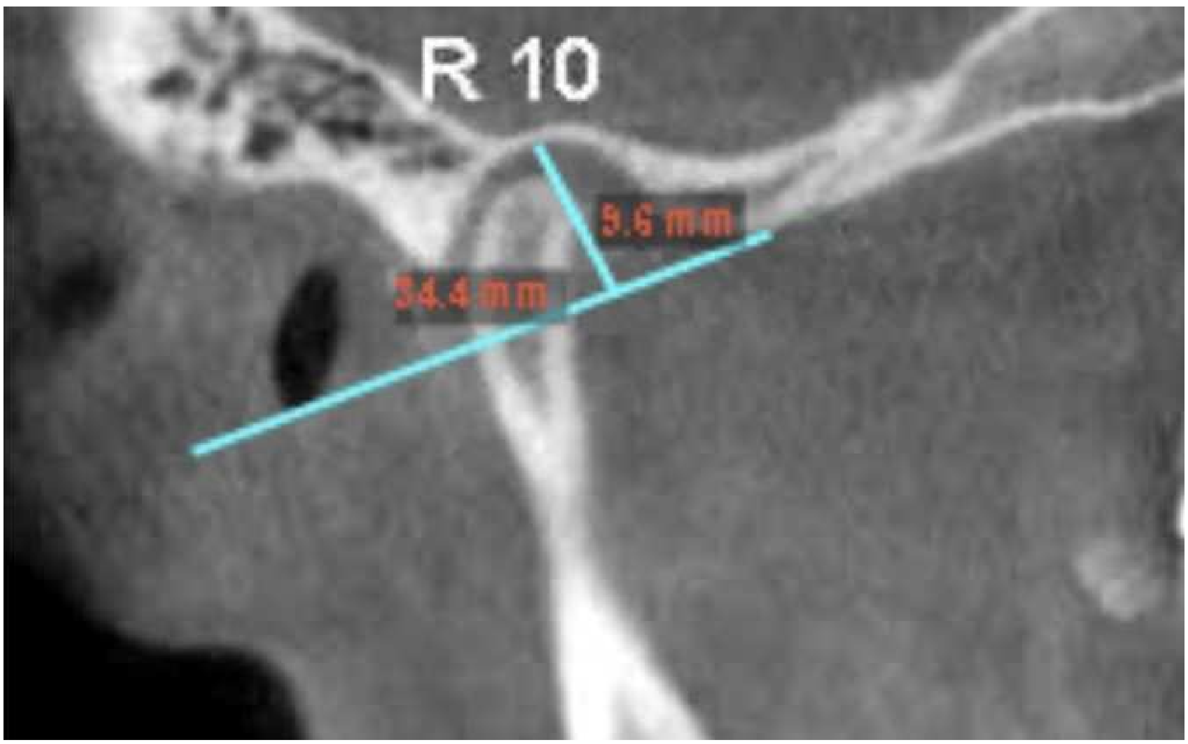

Figure 1. Sag Depth

Anterior joint space (Sag Ant): expressed by the shortest distance between the most anterior point of the condyle and the posterior wall of the articular tubercle (Fig 2a).

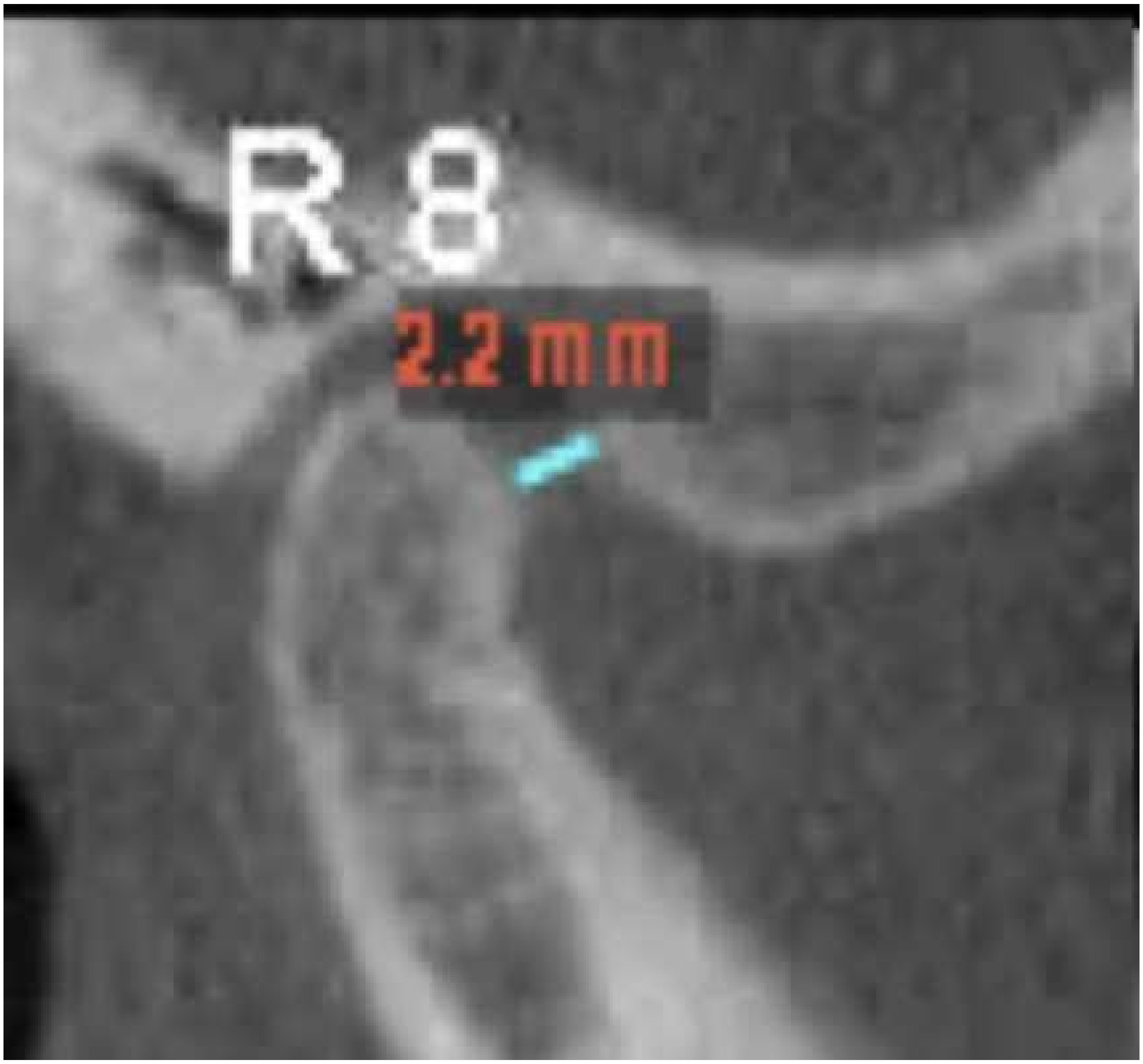

Figure 2a. Sag Ant

Superior joint space (Sag Sup): measured from the shortest distance between the most superior point of the condyle and the most superior point of the mandibular fossa (Fig 2b).

Figure 2b. Sag Sup

Posterior joint space (Sag Post): represented by the shortest distance between the most posterior point of the condyle and the posterior wall of the mandibular fossa (Fig 2c).

Figure 2c. Sag Post

Mediolateral width (MLW): The distance from the most prominent point of the medial pole to the most prominent point of the lateral pole was measured as the MLW (Fig 3).

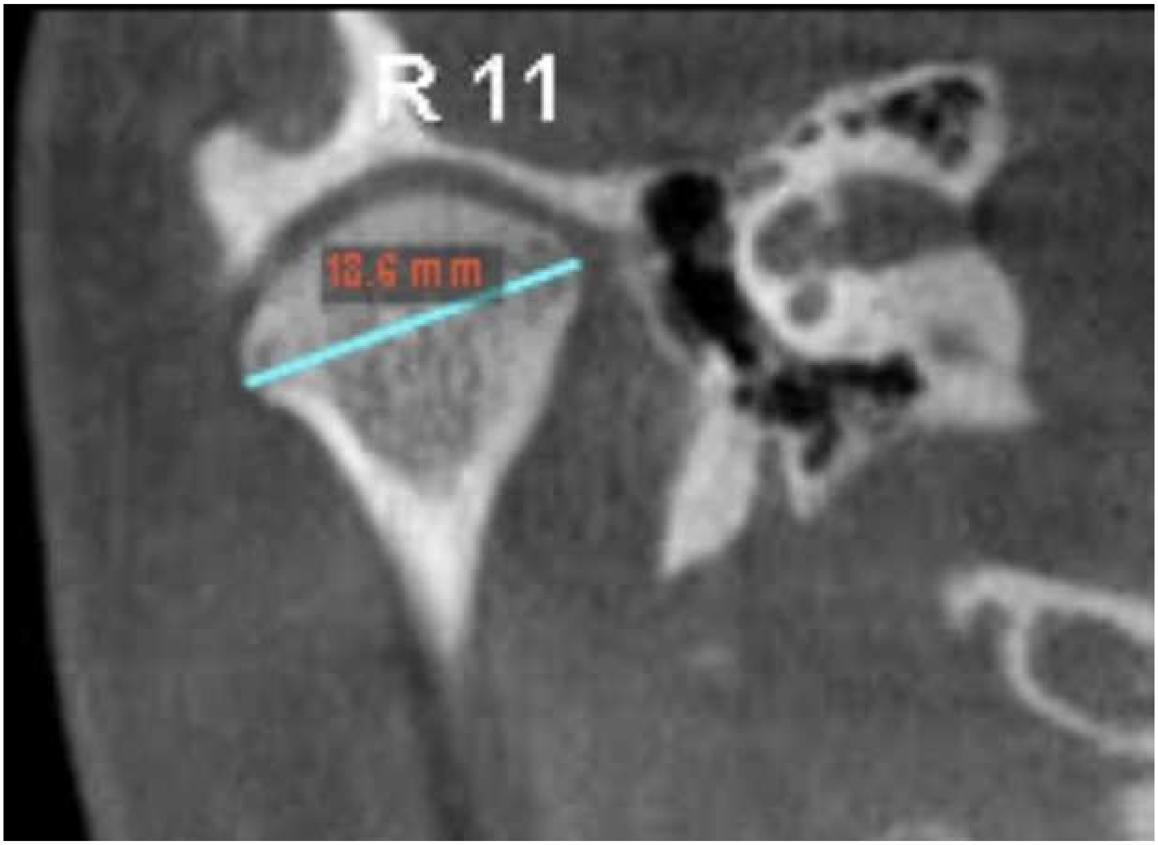

Figure 3. MLW

The axial angle of the condyle (Axl Angle): determined by the angle between the line connecting the medial and lateral pole of the condyle head and the midsagittal plane (Fig 4).

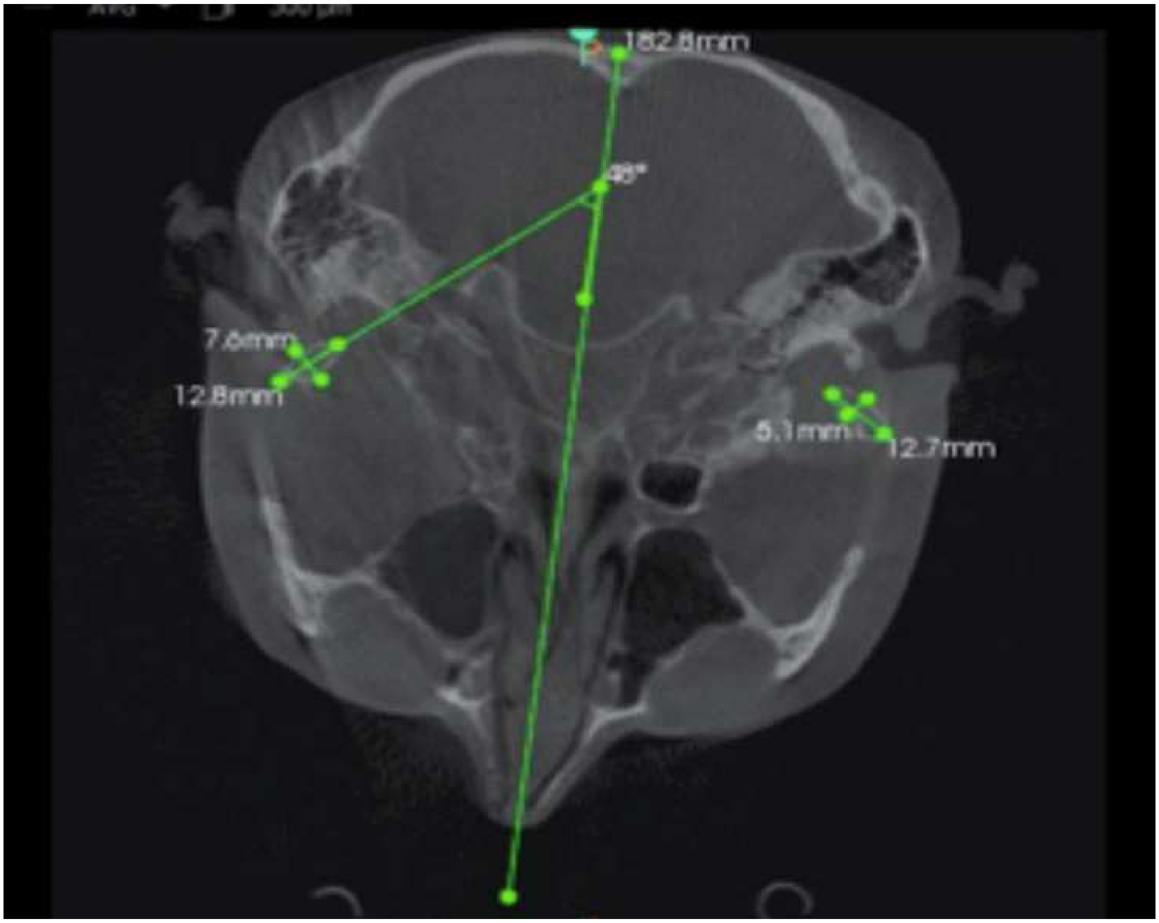

Figure 4. Axl Angle

A visually created gridline scale (Resorption Index) is created for two different views (sagittal and coronal) in order to grade the resorption of the temporomandibular joint (Fig 5a and b). The scale divides a circle into eight equal parts, and a score is given to each part according to whether resorption exists or not. If there is resorption in a part regardless of amount, 1 point is scored. The sum of both sagittal and coronal scores in the two views would decide the projected severity of resorption, classified as mild (2-4), moderate (5-8), or severe (9-16). A score of 0-1 would be considered normal.

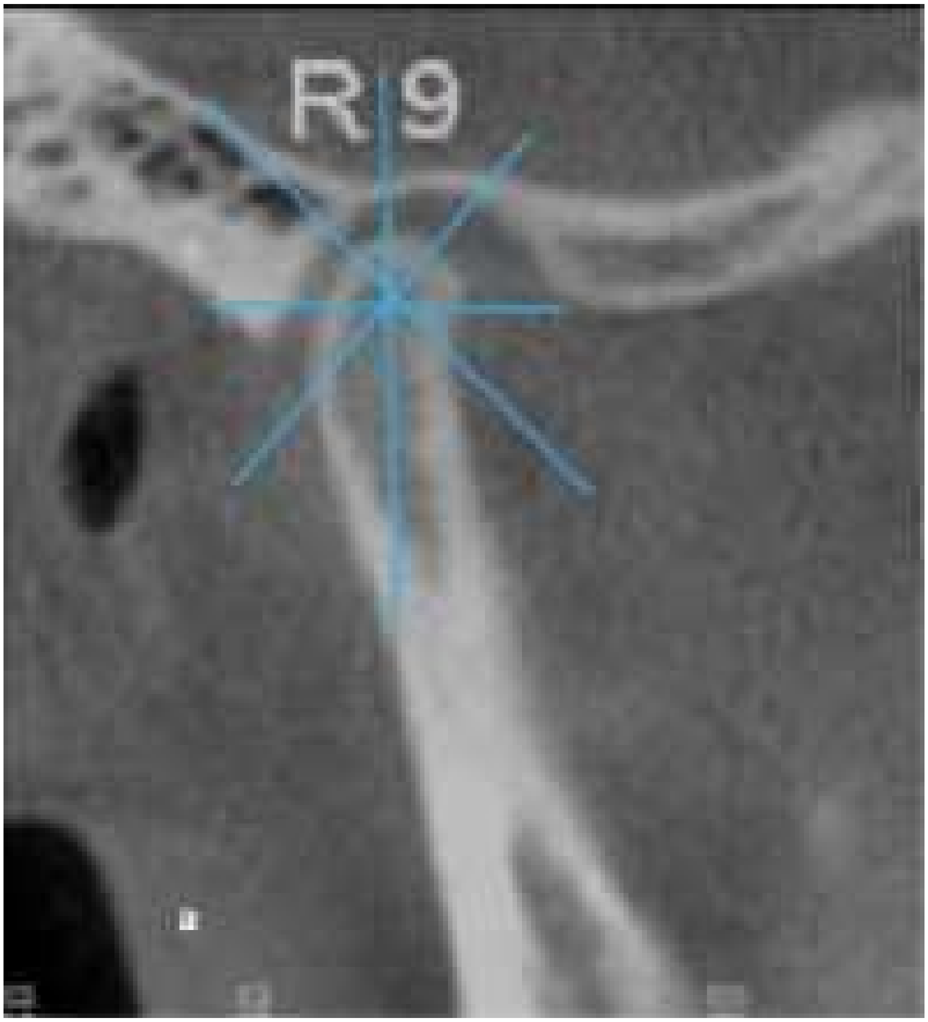

Figure 5a. Resorption Index in the Sagittal view

Figure 5b. Resorption Index in the Coronal view

For sagittal scoring, in the sagittal view, we recommended placing a gridline scale to the center of the condylar neck on the TMJ image slice which is derived from CBCT. If there is full resorption, 8 points are scored.

For coronal scoring, in the coronal view, we also preferred to place a gridline scale to the center of the condylar neck on the TMJ image slice which is derived from CBCT. If there is full resorption, 8 points are scored.

Statistical Analysis

In this study, we have had 34 observations for each of right and left group and thus having 68 observations in total when combined. Later, we applied a paired t-test to observe whether there exists a significant difference between the right joint and the left joint measures. The statistics found showed that the measures taken from the same patient differ for the left and the right joints, where TUKEY is used to adjust for multiple comparisons. Namely, the results found indicated that the measurements are significantly different from each other. Therefore, instead of using two observations per subject, which should have been analyzed using a repeated- measures ANOVA, we have separately analyzed the left and the right joints using a TUKEY- adjusted t-test for multiple comparisons. Pearson product-moment correlation coefficients (r) were determined to quantify the degree of correlation between the values obtained on the left and right sides for each measurement. Intra-rater reliability was assessed based on double measurements conducted more than 3 weeks apart for all 68 patients. The systemic intra- examiner error was evaluated at the significance level of 0.05—providing a 95% confidence in our decision-making process—and found to be statistically insignificant, indicating that there are no significant differences between the measures.

RESULTS

The study was comprised of 34 patients (mean age; 13 years 9 months, 6 boys, and 28 girls) diagnosed with JIA and 34 healthy subjects (mean age; 16.4, 15 boys and 19 girls). Table 1 presents the descriptive statistics.

Table 1. Descriptive statistics of study sample

	JIA	Healthy	P-value
Sample size (n)	34	34	
Gender			
Male	6 (17.7)	15 (44.1)	0.018
Female	28 (82.3)	19 (55.9)	
Age (yr)	13.9 ± 4.2	16.4 ± 8.5	0.1289

Abbreviations: NA, not applicable.

Data are presented as number (percentage) or mean ± standard deviation.

Thirty JIA patients were ongoing medical treatment by using different brands of a pharmaceutical drug when our study was completed.

Table 2 presents the bivariate associations between the study variables and resorption index. We obtained the intra-class correlation coefficients of 0.98, 0.97, 0.99, and 0.98 for Sag Depth and Sag Sup, Sag Ant, Sag Post and Resoption index, and MLW and Axl Angle, respectively, from the right side of condyle. Furthermore, the same intra-class correlation coefficient of 0.99 was observed for Sag Depth, Sag Sup, Sag Ant, Resorption Index and MLW variables, while obtaining an intra-class correlation coefficient of 0.98 for Sag Post and Axl Angle from the left side.

Table 2. Patients' characteristics vs Outcome variable

	Resorption Index	P-value
Sample size (n)	34	
Gender		
Male	15.56 ± 8.76	0.435
Female	18.1 ± 10.92	
Right Condyle		
JIA	4.26 (3.77)	0.0002
Control	1.17 (1.58)	
Left Condyle		
JIA	4.26 (3.78)	0.0003
Control	1.44 (2.13)	

Measurements from the Sag Depth, the three joint spaces, MLW, and Axl angle are shown in Table 3. These were the results found in the left side: The mean depths of the mandibular fossa were 8.96 and 7.97 mm for the control and JIA groups, respectively (P= .064, r= 0.0339). The mean of the anterior joint spaces was 2.36 and 1.81 mm for the control and JIA groups, respectively (P= .016, r= 0.1847). The mean of the superior joint spaces was 2.99 for the control group and 2.47 mm for the JIA group (P= .034, r= 0.0406). The mean of the posterior joint spaces was 2.54 for the control group and 2.63mm for the JIA group (P= .74, r= -0.0439). The mean of the mediolateral widths was 15.53 and 16.13 mm for the control and JIA groups, respectively (P=.46, r= =-0.1079). The mean of the axial angles was 54.64° for the control group and 48.61° for the JIA group (P= .006,r= 0.0867). Lastly, the mean score of the resorption index was 1.44 and 4.29 points for the control and JIA groups, respectively (P= .0003, r= =-0.2339).

Table 3. Analysis of the sag depth, anterior, superior and posterior joint space, mediolateral width, resorption index and axial angle measurements in the left condyle

	Mean	SD	P value	Pearson product moment correlation ,r
Sag Depth (mm)				
Control	8.96	1.7	0.064	0.0339
JIA	7.97	2.52		
Sag Ant (mm)				
Control	2.36	1.08	0.016	0.1847
JIA	1.81	0.69		
Sag Sup (mm)				
Control	2.99	0.95	0.034	0.0406
JIA	2.47	1.05		
Sag Post (mm)				
Control	2.54	0.88	0.74	0.0439
JIA	2.63	1.19		
MLW (mm)				
Control	15.53	3.81	0.46	-0.1079
JIA	16.13	2.65		
Axl Angle (◦)				
Control	54.64	9.2	0.006	0.0867
JIA	48.61	8.29		

Similarly, these measurements obtained from the right side are presented in Table 4. The mean depths of the mandibular fossa were 9.66 and 7.86 mm for the control and JIA groups, respectively (P= .0004, r= 0.2894). The mean of the anterior joint spaces was 2.34 and 2 mm for the control and JIA groups, respectively (P= .041, r= 0.0752). The mean of the superior joint spaces was 2.93 for the control group and 2.82 mm for the JIA group (P= .742, r= =-0.0458). The mean of the posterior joint spaces was 2.62 for the control group and 2.5 mm for the JIA group (P= .713, r= 0.3008). The mean of the mediolateral widths was 17.09 and 16.47 mm for the control and JIA groups, respectively (P=.33, r= 0.2592). The mean of the axial angles was 59.41° for the control group and 54.29° for the JIA group (P= .019,r= 0.0562). The mean of the resorption index was 1.17 and 4.26 points for the control and JIA groups, respectively (P= .0002, r= -0.1396).

Table 4. Analysis of the sag depth, anterior, superior and posterior joint space, mediolateral width, resorption index and axial angle measurements in the right condyle

	Mean	SD	P value	Pearson product moment correlation ,r
Sag Depth (mm)				
Control	9.66	1.5	0.0004	0.2894
JIA	7.86	2.33		
Sag Ant (mm)				
Control	2.39	0.81	0.041	0.0752
JIA	2	0.73		
Sag Sup (mm)				
Control	2.93	1.06	0.74	-0.0458
JIA	2.82	1.45		
Sag Post (mm)				
Control	2.62	1.18	0.71	0.3008
JIA	2.5	1.38		
MLW (mm)				
Control	17.09	2.68	0.33	0.2592
JIA	16.47	2.41		
Axl Angle (◦)				
Control	59.41	9.29	0.019	0.0562
JIA	54.29	8.54		

DISCUSSION

The purpose of the present investigation was to assess the condyle-fossa relationship and resorption on TMJ between patients with and without Juvenile Idiopathic Arthritis (JIA). We hypothesized that the existing of JIA would cause changing of condyle-fossa relationship and create resorption in condyle. The specific aims of the study were (1) to evaluate radiologic features of the temporomandibular joint in patients with JIA and without JIA, (2) to use a TMJ indexing system by using CBCT scans to compare JIA patients with condylar reabsorption and healthy patients. The present study showed that the JIA patients differed significantly from the healthy group regarding the depth of the mandibular fossa on the right side and anterior joint spaces, MLW, condyle angulation, and resorption on both sides.

It is a challenge for clinicians to clearly understand the TMJ morphology and its relative position. Knowledge on the spatial variations of the normal condyle-glenoid fossa relationship could allow the clinician to potentially identify the beginnings of degenerative joint disease or indicate problems already established which would allow for better treatment planning where obtaining values closer to normal is indicated.[40] Therefore, the correct identification of these values in conjunction with clinical observations could be of great importance for diagnosis and treatment planning in patients with condylar resorption.

The popularity of CBCT has recently increased for evaluation of condylar positions and morphologies because of the high-quality images and superior anatomic radiation doses in comparison with conventional computed tomography.[41] The reliability of CBCT measurements for the assessment of mandibular condyle morphology, across subjects and longitudinally, has been found to be acceptable in the literature.[42,43] The present study agreed with previous studies and supported that the reliability and reproducibility of CBCT in condylar measurements were excellent (intra-class correlations above 0.9). Our results for the depth of the mandibular fossa were not statistically significant in the left condyle but were significant in the right side when JIA and control groups were compared. Furthermore, the control group had more depth than the JIA group on both sides. In addition, the JIA group had very close results on both sides, which most probably occurred because of the flattening of the temporal bone. Our results support previous studies which presented flattening of the fossa/ eminence in patients with JIA.[9,44] The present study indicated that the JIA patients differed significantly from the control children in anterior joint spaces on both sides. According to Hu and Schneiderman,[45] the reduced joint space in the JIA group can be attributed confidently to the pathogenesis of JIA.

The results of the present study showed that the posterior joint space was not statistically significant between both JIA and control groups on both sides. Therefore, we may assume that the JIA group has more anterior resorption than the control group.

In the literature, there are many studies that were conducted to measure the condyle-fossa relationships between different malocclusions.[37,46] However, our study is the first to measure joint spaces in patients with JIA using CBCT. Those malocclusion studies stated that the condyles in the Class II and III groups had a shorter condyle to fossa distance than the condyles in the Class I group.[46,47] In our study, the control group had Class I malocclusion; however, we did not classify our JIA group based on malocclusions. For this reason, our study has limitations to exactly describe the cause of the significant difference in anterior joint spaces between JIA and control groups.

We found a significant difference in the MLW between the patients with JIA and in the control group on both sides. Somewhat unexpectedly, the MLW in the control group was bigger than in the JIA group on right side. On the contrary, it was smaller than the JIA group on the left side. In addition, the JIA group had very close length on both sides. Our study results did not agree with the findings of Kristensen et al[48] who found less condylar width in both sides with JIA patients than the control group.

The axial plane is the most appropriate way for evaluating symmetry between the condyles. Thus, we assessed the mediolateral aspect on both condyles in the axial plane. Significant differences were observed for the condyle angulation in relation to the sagittal midline for both sides (right and left) between the two groups. We assumed that alterations occurring on the condyle of patients with JIA can be a reason for having less angulation than the control group.

Although, several studies have used 3D indices to quantify CBCT changes to the dentition,[49,50] some studies have created a scoring or grading system to assess the morphology of it. Furthermore, there does not exist any index to evaluate deformity or resorption of TMJ in the literature. CE-KA TMJ index is the first index to grade changes in TMJ. Stoustrup et al[51] categorized condylar morphology and determined 3 definitions (0, A, B) of condylar scores by using CBCT images. First, surfaces with normal shape and intact outline were given a score of “0” and considered “normal”. Secondly, surfaces with a deformed or flattened intact outline were scored “A” and called “deformed.” Finally, surfaces that were not uniform or had an interruption in outline due to cysts or erosion was scored “B” and called “erosive.” In our study, we developed a CE-KA index which can allow differentiation in morphological changes of condylar shape with more details by using a scoring system. In addition, our present study has similarities with Stoustrup et al[51] since both studies used coronal and sagittal CBCT images. This present study demonstrated that there was a significant difference between the two groups. The JIA group had more resorption than the control group.

The results of the present study should be viewed within the limitations of the data. Firstly, the JIA group was still under treatment in the multidisciplinary Pediatric Rheumatology Outpatient Clinic and not assessed about how could treatment method, type of medication, and dosage of each medication affects osseous structures of the temporomandibular joint. Secondly, In the JIA group, all patients did not have class I malocclusion, and also a few of them was in the late mixed dentition. However, the healthy group had Class I molar and canine relationship with minor crowding.

CONCLUSIONS

In conclusion, the results of our study exemplified the destructive potential of juvenile idiopathic arthritis by using CBCT. In patients with JIA, the depth of the mandibular fossa and anterior joint space are less than the control group. It is most likely occurred due to the flattening of the fossa/ eminence. Decreased condylar angulation may be indicative of condylar alteration in the JIA group. JIA patients presented more resorption than the control group when utilizing the CE-KA index. CE-KA index can help practitioners score condylar resorption in patients with JIA. The study mainly focused on comparing condyle-fossa relationships between the JIA and the control groups. Therefore, in future studies, it may be of interest to compare right and left condyles in the same group by taking CBCT at different times so we can observe and evaluate the effects of JIA at particular time periods.

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APPENDIX A

INSTITUTIONAL REVIEW BOARD APPROVAL

THE UNIVERSITY OF ALABAMA AT BIRMINGHAM
Office of the Institutional Review Board for Human Use

470 Administration Building
701 20th Street South
Birmingham, AL 35294-0104
205.934.3789 | Fax 205.934.1301 | irb@uab.edu

APPROVAL LETTER

TO: Kau, Chung How

FROM: University of Alabama at Birmingham Institutional Review Board
Federalwide Assurance # FWA00005960
IORG Registration # IRB00000196 (IRB 01)
IORG Registration # IRB00000726 (IRB 02)
IORG Registration # IRB00012550 (IRB 03)

DATE: 16-Apr-2021

RE: IRB-300000795
IRB-300000795-022
A Study to Understand Temporomandibular Joint Function in Children with Juvenile Idiopathic Arthritis and Normal Children

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The IRB reviewed and approved the Personnel Amendment submitted on 07-Apr-2021 for the above referenced project. The review was conducted in accordance with UAB's Assurance of Compliance approved by the Department of Health and Human Services.

Type of Review: Expedited
Expedited Categories: 4, 5
Determination: Approved
Approval Date: 16-Apr-2021
Expiration Date: 03-Nov-2021

The following populations are approved for inclusion in this project:

- Children – CRL 1

Please note: Amendment requesting changes to study personnel (adding Adriana Buendia and Shubham Sharma).

Documents Included in Review:

- IRB PERSONNEL EFORM

Record Number
IRB-300000795
Done Save

A Study to Understand Temporomandibular Joint Function in Children with Juvenile Idiopathic Arthritis and Normal Children
Chung How Kau - Orthodontics (UAB DEPARTMENT)

Human Subjects
View Mode
Change Project Info

Submissions (27) Linkages Summaries ?

Home Summaries Personnel

Summary
Devices
Drugs
Personnel

Research Personnel

Add

All Certifications and Training

PI	Name	COI	Start Date		End Date
◉	Chung Kau - Orthodontics Role: PI	✓	13-Dec-2017	Retire	Remove
	Certifications and Training	Responsible Person ☑		CV Email	
○	Md Shahidul Ahsan - Temporary Services Role: Other Personnel	?	18-Jul-2019	Retire	Remove
	Certifications and Training	Responsible Person ☐		CV Email	
○	Virginia Behlen - Graduate School Dean's Office Role: Other Personnel	?	07-Mar-2019	Retire	Remove
	Certifications and Training	Responsible Person ☐		CV Email	
○	Timothy Beukelman - Ped - Rheumatology Role: Subinvestigator	✓	07-Mar-2018	Retire	Remove
	Certifications and Training	Responsible Person ☐		CV Email	
○	Ahmet Celebi - Orthodontics Role: Other Personnel	?	18-Jul-2019	Retire	Remove
	Certifications and Training	Responsible Person ☐		CV Email	
○	Randall Cron - Ped - Rheumatology Role: Subinvestigator	⚠	07-Mar-2018	Retire	Remove
	Certifications and Training	Responsible Person ☐		CV Email	
○	Matthew Gibson - Behavioral & Population Sciences Role: Other Personnel	?	06-Nov-2020	Retire	Remove
	Certifications and Training	Responsible Person ☐		CV Email	
○	Brian Kinard - Oral & Maxillofacial Surgery Role: Subinvestigator	✓	07-Aug-2020	Retire	Remove
	Certifications and Training	Responsible Person ☐		CV Email	
○	Melissa Mannion - Ped - Rheumatology Role: Subinvestigator	✓	07-Mar-2018	Retire	Remove
	Certifications and Training	Responsible Person ☐		CV Email	
○	Adriana Morales Buendia - Students Role: Other Personnel	?	10-Apr-2021	Retire	Remove
	Certifications and Training	Responsible Person ☐		CV Email	