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Assessment of Condylar Position in Centric Relation and Maximal Intercuspation in Different Types of Malocclusion Using Cone Beam Computed Tomography

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KEYWORDS

Lateral cephalograms, Dentofacial Orthopaedics, malocclusion

ABSTRACT:

Background: This study was conducted for the assessment of condylar position in centric relation and maximal intercuspation in different types of malocclusion using cone beam computed tomography.

Material and methods: Lateral cephalograms were taken for patients attending the Outdoor patient Department and the Department of Orthodontics and Dentofacial Orthopaedics, JCD Dental College, Sirsa. These individuals were screened on the basis of Steiners analysis for skeletal classification and were then divided into three groups as Group 1 - Class I Normal Occlusion, Group 2 - Class II Division1 Malocclusion and Group 3 - Class II Division 2 Malocclusion. The Lateral cephalograms of each group were taken with the subjects in Natural Head Position by the same operator with the film distance to the x-ray tube fixed at 5 feet. Fuji medical dry imaging X-ray film 8" × 10" were exposed at 60 to 90 KVP and tube current at 2 to 15 mA for 0.8 seconds. Lateral cephalograms were obtained from CS 8000C cephalostat machine manufactured by Care-stream Dental. (Fig.5). The radiographs obtained were traced on acetate tracing sheets of 0.003 inch thickness with a sharp 3H pencil on a viewbox. Linear and angular measurements were obtained nearest to 0.5mm and 0.5 degrees by ruler scale and protractor.

Results: Comparison of mean measurements obtained from all the groups in left frontal MI was done and result showed significant difference between group 1- Class I Normal occlusion, group 2- Class II Div.1 and group-3 Class II Div.2 malocclusion. (p=<0.001). The inter-group comparison of mean Left Frontal MI was done. The result showed a significant differencebetweenGroup1-ClassINormal occlusionandGroup3-ClassIIDiv.2malocclusion as compared to Group 2- Class II Div.1 malocclusion.

Conclusion: From the results of the present study, the following conclusions can be drawn from the evaluation of condylar position in Maximal Intercuspation (MI) and Centric Relation (CR) position in both lateral and frontal cuts of right and left TMJs in Class INormal occlusion, Class II Division1 malocclusion and Class II Division 2 malocclusion. Thisstudyfoundsomevariationsincondylepositioninboth CRandMI,even though these variations were statistically insignificant. The study found statistically significant difference in left lateral MI as compared to right lateralMIinGroup1-ClassINormalocclusionandGroup2-ClassIIDiv.1andalso foundstatisticallysignificantdifferencebetweenCRandMIonbothsidesinpatients with Class IIDiv.2.

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Introduction

The discipline of orthodontics is directed towards alteration of occlusion of teeth and the relationship of jaws. The orthodontist's goal of treatment is to achieve as near perfect occlusion as possible.[1] The problem-oriented approach to diagnosis and treatment planning has been widely advocated to overcome the tendency to concentrate on only one aspect of a patient's problems. The essence of the problem-oriented approach is to develop a comprehensive database of pertinent information so that no problems should be overlooked.[2] For orthodontic purposes, the database may be derived from clinical examination of the patient, and evaluation of diagnostic records i.e., dental casts, radiographs and photographs.

Diagnosis is the primary and most vital aspect of treatment planning because it not only concentrates on detecting dental malocclusion, but encompasses multiple other factors associated with stomatognathic system.[2]

The temporomandibular joint (TMJ) is one of the most complex joint both morphometrically and functionally and its harmonious functioning is very important to maintain normal occlusion and masticatory system.[3] When the jaw is in the closed-mouth position, the posterior band of the disc is located above or slightly anterior to the top of the condyle. The condyle–disc complex translates out of the fossa during mouth opening. Thus, the TM joint has the characteristics of a so-called hinge joint with a moveable socket that enables the masticatory system to perform such divergent functions as chewing and speaking.[4] Therefore, evaluation of TMJ and analysis of occlusion and jaw relationship is essential for successful treatment planning. Since orthodontic treatment has a very close relationship with all the components of masticatory system, therefore, one needs to understand various aspects of functional occlusion and utilize the knowledge to change static and functional occlusal relationships, fundamentally.[5] Unfortunately, there is no evidence that achieving 'optimal' occlusion has any influence upon long-term stability, masticatory function or the alleged association between orthodontic treatment and temporomandibular disorders. It is important to emphasise that it is necessary to carry out a full occlusal examination for all orthodontic patients. It is essential to record not only the patient's habitual bite but also to record the patient's ideal jaw relationship. Without doing this the orthodontist cannot fully assess a malocclusion or avoid a potential mistake in treatment planning.[1]

The mandible assumes two well-known positions in normal jaw movements, i.e., Centric Relation (CR) and Maximum Intercuspation (MIC). Centric Relation is the most anterior- superior position of the condyle in the fossa, seated against the articular disc, at the posterior slope of the eminence, centered transversely by coordinated masticatory muscles.[6] It is a musculoskeletal position, anatomically determined, repeatable and reproducible. It has also been described as the most stable and comfortable position of the mandible in which the joints can be loaded without discomfort. Centric relation is a fixed axial position of the condyles. This does not mean that the mandible is restricted to centric relation during function. The rotating condyles are free to move down and up the eminence to and from centric relation, permitting the jaw to open or close at any position from centric relation to most protruded. It is the universally accepted jaw position because it is physiologically and biomechanically correct and is the only jaw position that permits an interference-free occlusion.[7]

The Maximal Intercuspation position (MIC) refers to the occlusal relationship in which the teeth of both arches are mostly interposed and this position is dictated by the teeth. Tooth morphology and position are the primary influences determining the mandibular positions and movements. The condylar position is strongly determined by the dental contacts and intercuspitation through muscles and ligaments.[6]

The importance of centric relation has been debated for many years. It is taken as a key reference to analyse and reconstruct the masticatory system.[6] It is a position that is achieved when the operator takes the condyles and disc to the anterior wall of the fossae. Such position is disc oriented and is a very useful reference to check or modify inter arch relationships.

According to Ash, MIP rarely coincides with CR. For some authors the best condyle- fossa relationship is the one achieved in CR8. Dawson described centric relation as a maxillomandibular relationship, in which properly aligned condyle and disc are in most superior position in contact with the posterior surface of the articular eminence, irrespective of vertical dimension or tooth position. Lucia believes that the correct centric relation

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is essential for coordination of the occluding tooth surfaces and the temporomandibular joint.[9]

CR is the precise location of the horizontal condylar axis when properly aligned condyle- disk assemblies are completely seated in their respective bony sockets. Because the position of the horizontal condylar axis determines the maxillo-mandibular relationship during jaw closure, any variation in condylar position will change the closing arc of the mandible and thus affect the initial contact of the mandibular teeth against the maxillary teeth. If maximal intercuspal tooth contact is not coincident with the completely seated position of both condyles, the condyles must be displaced to achieve complete jaw closure into maximal intercuspation.[7]

Several studies have shown that CR-MIC discrepancies are frequently present in the general population, in symptomatic as often as in asymptomatic subjects, whether they are of a distinct facial pattern or not, and whether deprogrammed or not. Controversies still exists regarding ideal condyle-fossa relationship when the teeth establish MIC. The condylar position is directly related to how the teeth come together because the condyles and the teeth are connected with each other and move in tandem. Due to malocclusion, the condyles may not be located in centric relation in orthodontic patients before treatment.[6]

If any premature occlusal contact changes the jaw closing arc, the condyles might be displaced to achieve a maxillomandibular relationship in maximum intercuspation position to avoid premature contact.[6] The difference in the condylar position between the patient centric relation and centric occlusion might give a false picture of patient's actual malocclusion and its severity and may cause temporomandibular dysfunction (TMD). Therefore, to provide a proper treatment plan, the condylar position must be evaluated and a determination of centric relation is a reasonable prerequisite for the analyses of occlusion and jaw relationship.[7]

Accurate diagnostic imaging is an essential tool that allow an orthodontist to closely monitor treatment progress and outcome for diagnosis and treatment planning.[10] Lateral cephalometric radiographs have been used for many years for diagnosis of skeletal and dental discrepancies and is an essential clinical and research tool for diagnosing skeletal imbalance and for assessing skeletal growth and development.[11]

The gold standard method for cephalometric evaluation has not been defined yet. Traditional imaging methods have been questioned due to a higher probability of errors while identifying landmarks or making hand-traced measurements, and for the large amount of time consumed for the evaluations.[11] Diagnosis of temporomandibular joint is complicated and requires comprehensive clinical and radiographic analysis.[12] The 3D imaging technique has provided a new possibility for orthodontic diagnosis and treatment evaluation. The application of cone beam computed tomography (CBCT) to the craniofacial region provides an alternative to traditional computed tomography (CT) systems with the advantages of less radiation and lower billing costs.[11]

The analysis of joint space and condylar position is best done by using CBCT, as it provides reconstructed images of high quality with lower radiation dose at high resolution when compared to normal CT. The purpose of this study is to evaluate the condylar position and assess its position in centric relation and maximal intercuspation in different types of malocclusion by cone beam computed tomography for the analysis of occlusion and jaw relationship to provide a proper treatment plan.

Material and Methods

Lateral cephalograms were taken for patients attending the Outdoor patient Department and the Department of Orthodontics and Dentofacial Orthopaedics, JCD Dental College, Sirsa. These individuals were screened on the basis of Steiners analysis for skeletal classification and were then divided into three groups as Group 1 - Class I Normal Occlusion, Group 2 - Class II Division1 Malocclusion and Group 3 - Class II Division 2 Malocclusion.

The Lateral cephalograms of each group were taken with the subjects in Natural Head Position by the same operator with the film distance to the x-ray tube fixed at 5 feet. Fuji medical dry imaging X-ray film 8" × 10" were exposed at 60 to 90 KVP and tube current at 2 to 15 mA for 0.8 seconds. Lateral cephalograms were obtained from CS 8000C cephalostat machine manufactured by Care-stream Dental. (Fig.5). The radiographs obtained were traced on acetate tracing sheets of 0.003 inch thickness with a sharp 3H pencil on a viewbox. Linear and angular measurements were

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obtained nearest to 0.5mm and 0.5 degrees by ruler scale and protractor.

The impressions of upper and lower jaws were taken for all the individuals using hydrophobic addition cure silicone impression material. Addition silicon impression material was chosen as it has good tear strength as compared to alginate impression material. It also has highest dimensional stability even after 1 week, as compared to other impression materials. It is resilient and flexible so we can easily remove the impression from the mouth without tearing.

Impressions were poured in die stone (TYPE IV). It is the strongest dental material and has low expansion which provides accurate details of the dentition as compared to dental stone.

For the purpose of recording centric relation, Dawson's technique was used which is described below in detail. In this technique, an anterior deprogramming jig was used. The purpose of muscle deprogramming is to reduce masticatory muscle activity levels to eliminate muscle pain, tension or discomfort. It helps to allow for an accurate examination of the relationship of the maxilla to mandible with condyles in a fully seated position. For deprogramming the masticatory muscles, the patients were asked to relax the jaw with cotton rolls held in between their teeth for 5-10 minutes. Once it was made sure, that the musculature is relaxed and deprogrammed, bimandibular manipulation of mandible was carried out and the jig was prepared to record the centric relation position.

The jig was fabricated using chemically activated acrylic resin as its setting reaction was compatible with intra-oral use and it is harder and less brittle than impression compound.

Step one: The patient was reclined in supine position in dental chair while making sure that the chin was pointing up. A patient in supine position is more relaxed and in a better position for the operator to work while seated. Pointing the chin up, made it easier to position the operator's fingers on the mandible and prevented the tendency of the patients to protrude the jaw.

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Supine positioning of the patient in dental chair with chin pointing upwards.

Step 2: The patient's head was stabilized in lower position which was nearly at the level of the operator rib cage and forearm. The head was stabilized in a firm grip so it would not move when the mandible was being manipulated.

Patient'sheadinlowerpositionatthelevelofoperatorrib cageandforearm

Stepthree:

Aftertheheadwasstabilized,thepatient'schinwasliftedupa gaintoslightlystretch the neck. Operator was comfortably seated, with the patient low enough to allow the work with forearm approximately parallel to the floor.

Stepfour: The four fingers of each hand were gently positioned on the lower border of the mandible. The little finger was slightly behind the angle of the mandible. The pads of the operator's finger were positioned to be in alignment with the mandibular bone as if one was going to lift the head. All the four fingers were kept tightly together.

Stepfive: The operator's thumbs were brought together to be placed in the notch above the symphysis of the mandible without applying pressure and all the movements were made gently.

Stepsix: The jaw was manipulated with a very gentle touch so that it slowly hinges open and closed. Any pressure and jiggling was avoided, as that would activate the lateral pterygoid muscle response.

Slow hinging movements were used so that the muscles

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were not triggered into contraction because once these positioned muscles were stimulated to contraction, it would be very difficult to seat the condyles in to centric relation.

Stepseven: After it was felt that the mandible was hinging freelyand the condyles seemed to be fully seated up in their fossae, it was assumed that the mandible was positioned in centric relation.

Patient's head positioning with stretched neck with chin lifted upwards.

Positioning of the four fingers on the lower border of the mandible.

Placement of the operator thumb in the notch above the symphysis of the mandible

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Preparation of Jig

After the manipulation of the powder and liquid, the chemically activated acrylic resin was adapted to the upper central incisors during the plastic phase. The jig was extended from the vestibular to the palatine aspects of the incisors, with two sides converging to a wedge-shaped vertex. The individual was instructed to slowly occlude the lower central incisors on the vertexof the resin until the posterior teeth were approximately 1mm apart. The jig was adjusted with a pear-shaped tungsten drill so that it had only one contact point in the palatine wedge vertex against the lower central incisors, in the midline, when the mouth was closed, providing a 1-millimeter maximum disocclusion between the posterior teeth.

Chemically Activated Acrylic Resin Jig.

Adjustment of articulator

Before transferring the facebow registration on to an articulator zeroing of an articulator was doneboth thehorizontal and lateral condylar guidancevalues are set at zero. After thezeroingof an articulator was completed the facebow transfer was done.

Mounting the Castson Articulator

Face bow Transfer torelate the Maxillaon to the Articulator

1. Corident Slidematic facebow and articulator was used in this study. It is a semi-adjustable articulator and simple to use and acceptable for all the mountings.
2. A facebow fork was fitted to the upper arch. The bite registration wax on the fork was adapted to the upper teeth with no rocking.
3. Thebowwasfittedontotheshaftofthebitefork.Theearpieceswereinsertedintheear holes and held in position by the assistant.
4. The bow was leveled to the height where the pointer aligns with the mark on the face. Then the bow was secured in place by tightening the finger knobs in front.

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Corident Slidematic articulator

Face bow fork fitted to the upper arch.

Adjustment of the bow in place by tightening the finger knobs in front.

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The bite fork was then removed from the facebow. The jig and bite fork were then inserted into a positioner to be secured in place on the lower bow of the Coridentsemiadjustable articulator. This related the upper cast to the condylar axis.

The upper cast was joined to the upper bow of the articulator. The upper bow was locked in centric relation.

Wax bite record were taken to relate the lower cast to the upper cast in centric relation.Alu-waxwasusedinthepresentstudywhichhashighcoefficientofthermalexpansionandhigh resistancetoclosure.Thewaxwassoftenedattheedgesbyuseofagasburner.Itwasnot overheated. The wax was flamed from the both sides to produce shine and softened by heating.

Thewaxwaferwasplacedagainsttheupperarch,andcompressedlightlysothatthereare indentations on it.

Bite fork placement on the articulator

Removal of the bite fork from the face bow.

Joining of the upper cast to the upper bow of the articulator.

Mandible was manipulated in centric relation before the patient closed into the wax. It was made sure that the first premolars made a definite indentation which further ensured that theposterior teeth were recorded withindentationsandheldthecastsinastablerelationshipwithe bite record. While the wax was still warm, it was trimmed and placed back to the indentations of the buccal cusp tips so the fit of the bite record could be verified in the mouth. There were no voids or cracks between the teeth and the bite record for a perfect tooth-wax-tooth fit. After that the perfection of bite record was verified. The wax bite was then removed from the mouth andplaced into cold water to make it brittle hard.

The wax bite was then replaced back into the mouth for the verification. After that condyle was held firmly in centric relation while the mandible hinges to bring the teeth into maximal contact with bite record. Both sides of the arch contacts were verified simultaneously with no premature contact into the hard wax. Bite record was carefullyexamined to make sure that there would be no impingement of soft tissue. The wax was then placed back against the upper teeth and the mandible was closed into it to readapt it. The wax bite was then removed from the mouth and placed between the upper and lower casts. After that casts were mounted on a semiadjustable articulator in centric relation. With this mounting, the articulator could be opened or closed without changing the relationship of thecasts to the centric relation axis.

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Wax bite record in centric postion

Mounting of the lower cast in the centric relation

After that the protrusive condylar guidance of a patient was obtained in a edge to edge relation because in edge to edge only rotational moment of a condyle occurs with in the fossa. The edge to edge relation of a patient was obtained from interocclusal records which was taken with wax wafer.

Slide between protrusive record and maximal intercuspation were obtained, these protrusive bite records were placed on a mandibular cast on articulator and condylar inclination is adjusted until the maxillary cast get coincide in to that protrusive record and condylar inclination values werenotedonright side andleft side.Thesevalueswerethe protrusive condylar guidancevalues of semiadjustable type of an articulator.[39]After that the marking was done between maximal intercuspation and protrusive record on the incisal guide table. Slide between the both of them was measured by Vernier Caliper.

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Recording of the protrusive bite

Measurement of the slide between protrusive record and MI

TMJ scan of lateral and frontal aspect was done and measurements of four lateral and fourfrontal cuts were obtained of 180µm thick tomographic imaging slices. The cuts in each individual were specified as:

- Left Lateral Maximal Intercuspation
- Right Lateral Maximal Intercuspation
- Left Frontal Maximal Intercuspation
- Right Frontal Maximal Intercuspation
- Left Lateral Centric Relation
- Right Lateral Centric Relation
- Left Frontal Centric Relation
- Right Frontal Centric Relation

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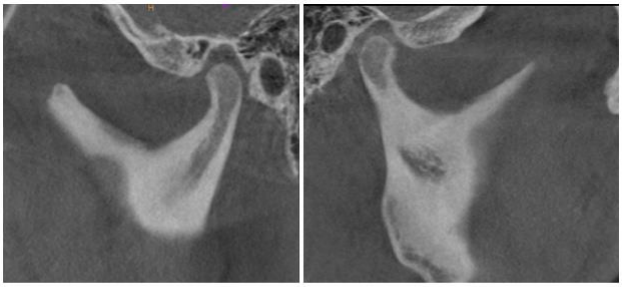
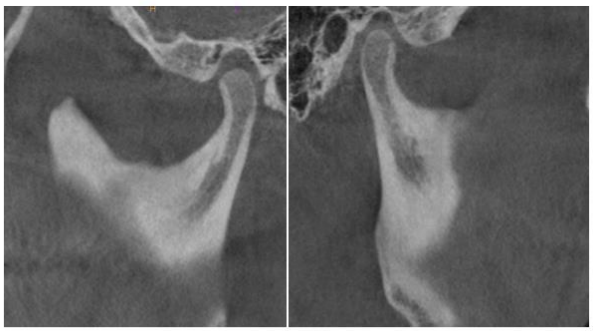


(a) (b)

Left and right Lateral MI

(a) (b)

Left and Right frontal MI



(a) (b)

Left and Right lateral CR

(a) (b)

Left and Right frontal CR

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Each of the 20 patients underwent two cone-beam computed tomographic examinations of the temporomandibular joints (TMJs), the first in MI and the second in CR. Lateral and frontal cone beam scans were obtained of the patients in standing position. Patient was exposed by the CS- 9300 CBCT machine manufactured by Carestream at 60 to 90 KVP and tube current at 2 to 15 mA for 8 seconds.

CS-9300 CBCT Machine

For the first scan, the patient was instructed to stabilize his/her occlusion in the maximal intercuspal position and for the second scan, the patient was instructed to open his/her mouth so that the operator could adjust the JIG in the upper central incisors.

Positioning of the subject in Maximal intercuspation in CBCT

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Positioning of the subject in Centric relation with Jigin CBCT

Results

The study comprised of 60 young asymptomatic individuals with age ranging from 18-23 years. The sample for evaluation of condylar position between CR and MI in individuals with different skeletal patterns were divided into three groups i.e. Group 1 - Class I Normal Occlusion, Group 2 - Class II Division1 Malocclusion and Group 3 - Class II Division 2 Malocclusion, consisting of 20 individuals in each group. Four frontal and four lateral cuts were obtained from the left and right TMJs of the individuals in MI and CR position.

Comparison of mean measurements obtained from all the groups in left frontal MI was done and result showed significant difference between group 1- Class I Normal occlusion, group 2- Class II Div.1 and group-3 Class II Div.2 malocclusion. (p=<0.001).

Table 1: Comparison of mean measurements obtained from all groups in left frontal MI. One-wayANOVAtest.(F=19.303),(p=<0.001)

	LeftFrontalMI			
	Mean	**Std. Deviation**	**F-value**	**p-value**
Group 1- Class I Normal occlusion	2.56	0.71	19.303	<0.001*
Group2-ClassII Div.1 malocclusion	1.90	0.39		
Group3-ClassII Div.2 malocclusion	2.42	0.68		

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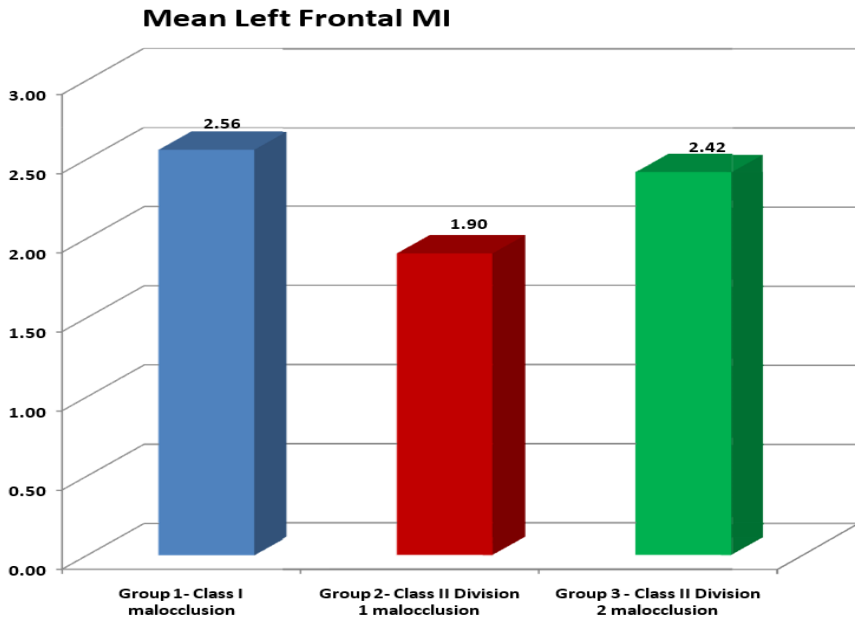

Comparison of mean measurements obtained from all groups in left frontal MI.

The inter-group comparison of mean Left Frontal MI was done. The result showed a significant difference between Group1-Class I Normal occlusion and Group 3- Class II Div. 2 malocclusion as compared to Group 2- Class II Div.1 malocclusion.

Table 2: Intergroup comparison of left Frontal MI. Post-hocbonferronitest(p=<0.001)

		Left Frontal MI	
		Mean Difference	**p-value**
Group 1- Class I Normal occlusion	**Group2**-ClassII Div.1 malocclusion	0.66	<0.001*
Group 1- Class I Normal occlusion	**Group3**-ClassII Div.2 malocclusion	0.14	0.597
Group2- Class II Div.1 malocclusion	**Group3**-ClassII Div.2 malocclusion	-0.51	<0.001*

Comparison ofmean measurements obtained from all thegroups in left lateral MIwas done. The result showed significant difference in mean Left Lateral MI (mm) between Group 1- Class I Normal occlusion, Group 2- Class II Div.1 malocclusion and Group 3 - Class II Div.2 malocclusion.

Table 3: Comparison of mean measurements obtained for all groups in left lateral MI. One-way ANOVA test.(F=6.895),(p=0.001)

	Left Lateral MI			
	Mean	**Std. Deviation**	**F-value**	**p-value**
Group 1- Class I Normal occlusion	2.38	0.65	6.895	0.001*
Group2-ClassII Div.1 malocclusion	2.02	0.42		
Group3-ClassII Div.2 malocclusion	2.27	0.55		

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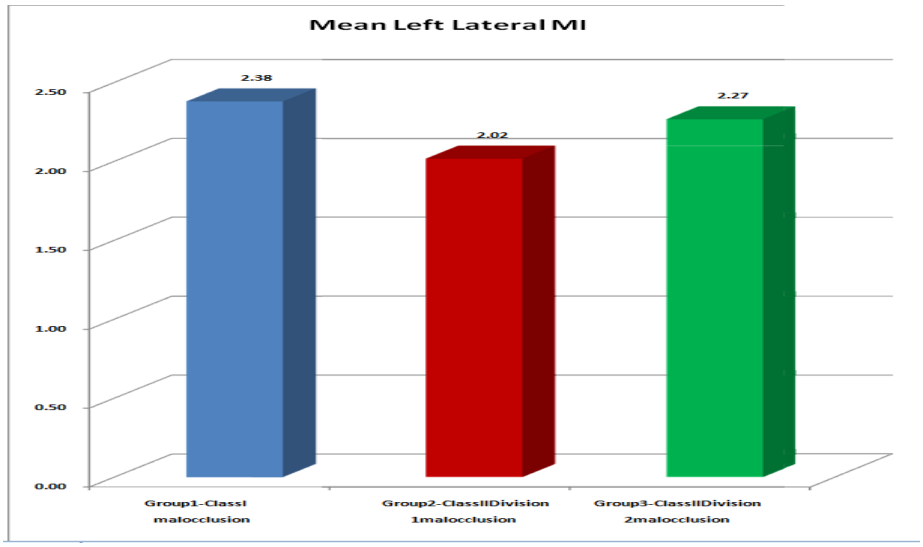

Fig.37 Comparison of mean measurements obtained for all groups in left lateral MI.

The inter-group comparison of mean Left Lateral MI was done. The mean Left Lateral MI was significantly more among Group 1- Class I Normal occlusion and Group 3 - Class II Div.2 malocclusion as compared to Group 2- Class II Div.1 malocclusion.

Table 4: IntergroupcomparisonofleftFrontalMI.Post-hocbonferronitest(p=0.001)

		LeftLateralMI	
		Mean Difference	**p-value**
Group 1- Class I Normal occlusion	**Group2**-ClassII Div.1 malocclusion	0.36	0.001*
Group 1- Class I Normal occlusion	**Group3**-ClassII Div.2 malocclusion	0.11	0.778
Group2-ClassII Div.1 malocclusion	**Group3**-ClassII Div.2 malocclusion	-0.25	0.040*

Comparison of mean measurements obtained from all the groups in left frontal CR was done.The result showed significant difference in mean Left Frontal CR between Group 1- Class I Normal occlusion, Group 2- Class II Div.1 malocclusion and Group 3 - Class III Div.2 malocclusion.

Table 5: Comparison of mean measurements obtained for all groups in left frontal CR. One-way ANOVA test.(F=39.343),(p=<0.001)

	LeftFrontalCR			
	Mean	**Std. Deviation**	**F-value**	**p-value**
Group 1- Class I Normal occlusion	2.73	0.72	39.343	<0.001*
Group 2- Class II Div.1 malocclusion	2.10	0.33		
Group 3- Class II Div.2 malocclusion	2.05	0.20		

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Table 6: Comparison of the mean measurements(mm) obtained for patients with Class II Div.2 malocclusion in the MI and CR positions on right side.

		Mean	Std. Deviation	Mean difference	t-test value	p-value
Right Lateral Anterior	MI	2.40	0.10	0.20	8.718	<0.001*
	CR	2.20	0.21			
Right Lateral Posterior	MI	2.10	0.10	-0.15	-1.868	0.077
	CR	2.25	0.26			
Right Lateral Superior	MI	2.20	0.31	-0.25	-21.794	<0.001*
	CR	2.45	0.36			
Right Frontal Lateral	MI	1.95	0.36	-0.15	-13.077	<0.001*
	CR	2.10	0.41			
Right Frontal Medial	MI	2.40	0.31	0.60	5.231	<0.001*
	CR	1.80	0.21			
Right Frontal Superior	MI	2.25	0.05	0.40	3.487	0.002*
	CR	1.85	0.46			

Discussion

Much of the investigative work aiming at determining the quantitative discrepancies between the CR and MI maxillomandibular positions. It was based on different conceptions of centric relation, registration techniques and methodologies used to estimate the reproducibility of the condyle/glenoid fossa relationship, either through articulators or by means of radiographs obtained under varying degrees of magnification and restricted to the two-dimensional plane. The limitations of these methods used to examine TMJ anatomy are subject to much controversy and debate in scientific circles, warranting further clarification.[13]

Many studies had assessed condylar position and morphology with conventional tomography. However, margins of the joint structures were unclear due to large slice thicknesses ranging between 1.0 and 3.0 mm. To take coronal images by conventional tomography, the patient had to be positioned in the machine with the mouth open and the head tilted up, precluding the imaging of the joint in intercuspal position.[14] In the present study we have taken 180µm thick slice, in which the margins of the joints were very clear for the assessment of condylar position. The introduction of cone-beam computerized tomography, a reliable and affordable three- dimensional diagnostic tool, created the possibility of faithfully reproducing any anatomical condition of the craniofacial complex. It is well known that spatial variations in the position of the condyle relative to the mandibular fossa in the CR and MI maxillomandibular positions are mostly very small on the order of millimeters and occur in approximately 90% of the entire population.[13]Girardot (2001)[15]concluded that the MPI instrumentation is a more reliable method to assess changes in condylar position than tracings of oriented tomograms, and he questioned the validity of using tomographic x-ray tracings to measure small changes in condylar position.[15] Even though we used one of the most advanced imaging methods available for application in Dentistry, Ethical Committee determined that our sample be reduced to 20 individuals because of the exposure of human subjects to X radiation.[13]

The axial slice is most appropriate to assess the symmetry between the condyles in anteroposterior and mediolateral aspects because it shows both condyles in the same image and allows the determination of reference planes. This also permits measuring the real dimensions of the condyles and their angulations.[16] Our findings show statistical significant difference between left and right condylar process in CR and MI position in Class I normal occlusion.

The sagittal slice is the most appropriate for assessing the condyle -fossa relationship. It allows the analysis of condylar concentricity by comparing the anterior and posterior condylar spaces.

The depth of the mandibular condyle fossa can also be determined by this technique.23 Our result showed no statistically significant difference between left and right side for the anterior and superior articular space. The

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evaluation of the condyle concentricity showed that both sides had non concentric positioning of the condyle. They were more anteriorly positioned in the mandibular fossa. Pullinger et al(1987)[9]showedthat anterior positioning of the condyles is characteristic of a Class II Division 1 sample. Vitral et al (2002)[17] with the same methodology used in this study, found a more anterior condylar position bilaterally in subjects with Class II Division 1 subdivision malocclusion.

The magnitude of the CR-MI discrepancy at the condylar level has an influence on occlusal relationships changing the type or severity of malocclusion, depending on the mandibular position adopted during the analysis. It cannot be quantified directly in the mouth because of some structural features, such as facial type, gonial angle, and occlusal plane inclination, all of which will also influence the resulting malocclusion. This means that patients with distinct facial characteristics will demonstrate larger or smaller differences between arch relationships, even in the presence of the same amount of condylar displacement.Toaccurately study the dental interarch and condyle positional changes between MI and CR, it is important to use a method that reduces or eliminates the influence of the occlusion on the musculature. A number of studies have shown that the neuromusculature positions the mandible to achieve maximum intercuspation, regardless of the position of the condyles.[18]The constant repetition of the proprioceptive trigger receptors to the muscles cause them to become patterned to the deviated closure, and these memorized patterns of muscle activity are called muscle splinting or 'engrams.' The resultant muscle function can be so dominant that the acquired mandibular position will often be mistaken by the clinician for the seated condylar position.[18]

Neuromuscular deprogramming is the key to reproducibility so that the condyle can be accurately seated. In the present study we have done muscle deprogramming to reduce masticatory muscle activity levels to eliminate muscle pain, tension or discomfort. It helps to allow for an accurate examination of the relationship of the maxilla to mandible with condyles in a fully seated position. Mounting dental casts in CR is helpful to show discrepancies and may reveal a malocclusion more obviously than might be seen when the teeth are in CO.[19]

Numerous studies have reported that the majority of patients with a natural dentition show a discrepancy between the occlusal position of the mandible in CR and MI by Posselt (1952),

Hodge &Mahan (1967) and Rieder (1978). This discrepancy is present in at least 90% of dentitions, and Posselt (1952) indicated that the antero-posterior distance between the CR and the ICP position was about 1·25-mm (91%) on average. This discrepancy was found to remain constant even following successful orthodontic treatment.[20]

The significance of the discrepancy is based on the presence of premature contacts, so that the patient is only able to find a stable occlusal position during closure in CR by sliding into MI. Premature tooth contacts in general, and premature contacts during closing in CR in particular, might be trigger points for para-functional activities like clenching and bruxism.[20]

One of the most often quoted studies in the field of CR–CO is by Glickman et al. (1974). In this study a completely reconstructed, natural dentition was studied under conditions of actual function to determine which of the two occlusal relationships the patient used during chewing and swallowing. They found that the prosthesis with intercuspation in CR did not alter the tendency for tooth contacts to occur in the patient's CO. It was suggested that the use of CR as a reference position is doubtful because the distance to the existing CO position is variable and unpredictable.

Rosner & Goldberg (1986) designed a study to investigate the three-dimensional differences between CR and CO. A custom made Buhnergraph on a Whip-Mix articulator was used to indicate the differences. There was no CO marking on the posterior superior quadrant suggesting that CO is unlikely to be posterior and superior to CR.

Shildkraut et al. (1994)[21] were among the orthodontists who strongly believed that hand held articulated casts used routinely in orthodontic treatment planning should be replaced with the so- called prosthodontic mounting with facebow and CR records. They hypothesized that: providing statistically significant differences exist between CR and CO, this could affect the diagnosis and treatment planning necessary to correct the malocclusion.

A similar study to Shildkraut was performed by Utt et al. (1995) but did not include any radiographic assessment. They measured CR–CO discrepancy on 107

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patients and related it to the age, sex, type of occlusion and ANB angle. Averages of antero-posterior (0·61 mm), supero- inferior (0·84 mm) and lateral (0·27 mm) mandibular shifts from CR to CO were reported. They indicated a weak correlation of magnitude and direction of CR–CO differences between right and left TMJs. They suggested that mounted study casts should be part of the examination and treatment planning.

Three-dimensional evaluation of the models showed that in most of the subjects in all the groups premature occlusal contact was on the posterior-most tooth, which is in agreement with previous studies.[15,19]Okeson has described how a premature posterior contact can cause the condyle to displace from the disc as the mandible pivots from this premature occlusal contact and moves into maximum intercuspation. The body of the mandible and the mandibular dentition move upward and forward from the initial premature occlusal contact in the CR to MI. Thus detection of this premature occlusal contact is vitally important for diagnosis.[22]

There is very little correlation between right and left sides for magnitude or direction of CO-CR differences. The highest correlation was found between the magnitude of CO-CR difference of left side and right side. In present study there was a significant difference between CR and MI on left and right side in all the groups. Previous authors have advocated use of diagnostic study models mounted in centric relation to make a complete diagnosis. They have concluded it is difficult, if not impossible, to quantitatively assess a CO-CR discrepancy clinically.[23] Dawson[7]considers it "... a mistake to neglect the kind of careful analysis that is possible only when casts are mounted in centric relation with a facebow transfer." Okeson[22]advocates the use of mounted casts since the protective reflexes of the neuromuscular system may prevent detection of interferences clinically. Orthodontists have not completely ignored this goal. Parker (1978)[24]suggested that for many patients study casts be placed on an adjustable articulator in centric relation to see if it coincides with centric occlusion.

In the present study, we compared each measurement mean found in the MI and CR positions, considering the whole sample and individual groups. In most cases, the mean measurement values were different. These results agree with Weffort SY et al (2010)[6] and Ikeda et al (2011)[25], who recognize the existence of discrepancies between the two positions. Their results showed statistically significant between CR and MI at the condylar level in symptomatic and asymptomatic individuals. However, these differences were not statistically significant, in either the lateral or the frontal cuts.[20,27] This may have occurred because the differences between MI and CR are generally very small. In our study these differences may have been even smaller owing to the relatively higher accuracy of the imaging method we used, as compared to those used in several other studies by Utt TW et al (1995)[26] and Hidaka O (2002)[19] et al, namely the methods of conventional radiographic examination and models mounted on articulators. They used the mandibular position indicator (MPI) to compare condylar position between CR and CO.

Some of the studies by Weffort SY et al (2010)[6] and Ikeda K et al (2011)[14] found statistically significant differences between the MI and CR positions. Our study also found statistically significant difference between CR and MI in frontal and lateral cuts.

Our research sample consisted of young asymptomatic adults having all permanent teeth (except third molars) and no periodontal disease, whereas other research was conducted with older patients displaying symptoms of TMD and missing teeth. The clinical applicability of these maxillomandibular positions is also subject to widely differing opinions because of the existence of contradictory results in the literature by Carlsson GL[27] and Keshvad A.[20]

Wood GN (1988)[28] and Carlsson GL (2007)[27] opposed to using CR in various oral rehabilitation procedures, on account of the conceptual differences observed throughout history regarding a true CR position, varied reproducibility rates, nearly negligible discrepancies between the RC and MI positions, the lack of scientific evidence supporting the assumption that condylar position and orthodontic treatment may be related to TMDs, and the limitations of articulators to reproduce TMJ anatomy and function.[27,28]

Wood GN (1988)[28] and Carlsson GL (2007)[27]however, have reported more balanced views, admitting that both CR and MI may be used in oral rehabilitation according to each patient's specific situation. According to this view, extensive prosthetic restorations, occlusal adjustments, parafunction management, rehabilitation after orthognathic surgery, unsatisfactory MI, TMD management, and orthodontic therapy of greater complexity would be indications for using CR. In

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contrast, less extensive oral rehabilitations, a stable MI position, the absence of signs and symptoms, and less complex orthodontic therapy would be indications for using MI.[27,28] Frequency, magnitude, or direction of CO-CR changes at the condylar level could not be predicted by age, gender, Angle classification, ANB angle, or mandibular plane angle, in accord with the study of Utt et al (1995).[26] In present study the results showed statistically significant between CR and MI in males in all the groups as compared to females.

Based on the results of the present study, the latter approach seems to be a more logical choice. Despite the limitations previously discussed, the absence of symptoms and the relative similarity of results in our study sample suggest the existence of a relative balance capable of preventing pathologic changes in the condyle/fossa relationship, a balance which could be maintained after low complexity procedures.

Conclusion

From the results of the present study, the following conclusions can be drawn from the evaluation of condylar position in Maximal Intercuspation (MI) and Centric Relation (CR) position in both lateral and frontal cuts of right and left TMJs in Class INormal occlusion, Class II Division1 malocclusion and Class II Division 2 malocclusion. This study found some variations in condyle position in both CR and MI, even though these variations were statistically insignificant. The study found statistically significant difference in left lateral MI as compared to right lateral MI in Group1-Class I Normal occlusion and Group2-ClassII Div.1andalso foundstatisticallysignificantdifferencebetweenCRandMI onbothsidesinpatients with Class IIDiv.2.

Conclusion can be drawn from sexual dimorphism and variations in Class I Normal occlusion, Class II Division1 malocclusion and Class II Division 2 malocclusion groups. Ourstudyfoundstatisticallysignificantdifferenceamongth emalesinall thegroupsas compared to females between CR and MI position. Within the limitations of this study, it can be concluded that there were no significant condyle/ mandibular fossa relationship discrepancies between the centric relation and the maximum intercuspation positions in asymptomatic patients with practically intact dentitions, using cone- beam computed tomography.

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