The Reproducibility of Condylar Hinge Axis Positions in Patients, by Different Operators, Using the Electronic Mandibular Position Indicator

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Three operators each made five recordings from 15 symptomatic patients using the electronic mandibular position indicator. The method consisted of measuring bilateral spatial changes of the hinge axis recalculated by the computer to an intercondylar distance of 110 mm and a third position, calculated from the rotation of the hinge axis, at the incisal guidance table. All individual patient recordings were related to the origin of the same coordinate system. This origin is designated and defined as the reference position, with purposeful elimination of any stated joint position for this definition. The measurements were in all planes of space at 10-millimicron increments, including the rotation of the transverse hinge axis in hundredths of degrees. These data showed that the reproducibility of hinge axis positions, ie, reference positions, to hinge axis condylar positions dictated by the maximum intercuspation of teeth was in average less than 0.2 mm for each record from all operators and patients.

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The hinge axis of the condyles was first described in 1860 by Langer,[1] who used adjustable needles to locate a position of pure rotation in the condyles of cadavers. Since that time, the scientific validity and physical usage of the hinge axis have been well documented in the literature. The contemporary classification of this joint is ginglymoarthrodial, specifically denoting its rotational and translatory capabilities. Several researchers have reported on the differences between the maximum intercuspal position (ICP) and a form of reference position.[2–9] This reference position has been obtained using various methods and has been referred to as centric relation. Centric relation has been defined in the Glossary of Prosthodontic Terms, in which the term is also said to be in transition to obsolescence.[10] The researchers mentioned above utilized intraoral occlusal records to mount casts and compare positions. These investigators then quantified differences, using specialized instrumentation, between the reference position (RP) of sorts and ICP. These methods of measuring RP → ICP have been highly scrutinized by questioning the errors induced by materials, influence of operators, and state of pathoses of the patient. The present study employed a method that eliminates the former concern and addresses the other two. It was the purpose of this study to check if there is reproducibility of RP → ICP in symptomatic patients using different operators on the same patient. This project did not investigate a reproducible position of the jaw, but

the reproducibility of the movement between two positions (RP and ICP).

The necessity for these data in diagnosis was established by Gerber[3] and Pullinger.[11] Gerber considers a parafunctional position as being iatrogenic with symptoms manifested by muscle tension, myogenesis pain, neural muscle imbalance, and the loading of the joint. Pullinger showed bilateral condylar discrepancies in patients with unilateral TMJ symptoms and conjectured on the predisposition of the unaffected side to similar pathology. This was based on posterior condylar positioning initiated from an unstable ipsilateral meniscus to condyle relationship by the contralateral side. Slavicek[12–14] routinely incorporates RP → ICP data in diagnosis and then verifies treatment with these data. This descriptional spatial diagnosis is part of an orthopedic standard analysis of mandibular positions and movement similar to the neutral zero method used in general orthopedics for joint mobility examination.

Materials and Methods

The electronic mandibular position indicator (EMPI) examination is a routine part of the computerized axiographic examination (CADIAX). The CADIAX system uses a cranial and mandibular facebow. The cranial facebow carries sagittal recording plates on which double recording styli trace mandibular movements. These styli are attached to the mandibular facebow, which is connected to the mandible by a functional occlusion clutch that does not interfere with maximum ICP.[15] It is designed to be a diagnostic means for TMJ function and pathology including other associated structures, such as muscles and teeth. The EMPI quantifies changes in the hinge axis positions located and stored by the computerized axiograph.

The use of a functional occlusion clutch allows maximum ICP of the occlusion in vivo. The EMPI will measure any discrepancies by 10 millimicron increments from all planes of space. Many assessments of joint positions are now possible. The classical analyses, within the orthopedic exam, consist of: RP → ICP, Joint Resiliency, Estimated Therapeutic Position, Power Bite, Ideal Vertical Position, and ICP → ICP after opening.

Data derived from this research eliminate concern over errors induced by materials; all data were collected in vivo without use of casts and articulator mountings. Operators were compared to one another using the same patient at the same origin of the computer's Cartesian coordinate system.

The 15 patients were taken at random from the unsolicited population presenting at the clinic. Some patients were postsurgical or orthodontically treated. All patients had signs and symptoms of craniomandibular disorders including: myofascial pain, masticatory muscle disorders, joint clicking, hypermobility of the joints, and postsurgically adhesions. The axiograph with the computer-interfacing electronics was assembled on each patient in the customary manner. The patients were given a routine CADIAX and instructed on the procedure for the EMPI examination.[13] A functional occlusion clutch was used for all patients. The yoke of this brass clutch was hand bent to within 2 mm of the buccal and labial surfaces of the teeth. Finite adaptation was accomplished without pressure using autopolymerizing acrylic, and the clutch was luted to the buccal and labial surfaces by cyanoacrylate free from maxillary antagonists.

The patients were asked to go to RP, open and close, and go again to RP. An analysis of the repeatability of RP was made for each patient from several recordings before recording RP → ICP movement. The data for this project consisted of recording the RP from operator guidance to an unguided ICP final position. The RP used was light chin point guidance to an unstrained retral position of the mandible at a vertical determined by the mandibular position before first contact of any two opposing teeth. The technique was described by Kantor et al,[16] Lauritzen,[17] Gilboe,[18] and Slavicek.[12] Three operators made five RP → ICP recordings for each patient. The operators did not receive any feedback from the instrumentation to be guided for selection of RP. The reference position is a joint-oriented position obtained by light chin point guidance.

Records

Each patient's record had 15 recordings of the RP → ICP hinge axis movements. These data were in all planes of space from three Cartesian coordinate systems for each recording. The recordings consisted of the first hinge axis position (RP) as being the origin of each coordinate system, and the second position (ICP), 4.5 seconds later, as the comparative second position. The computer then quantified the change in these two positions. All data were given in hundredths of millimeters or degrees.

Records were made of:

ΔXR change of hinge axis at the right condyle in X-direction (ie, anteroposterior) in mm

ΔZR change of hinge axis at the right condyle in Z-direction (upward, downward) in mm
ΔY change of hinge axis of lateral displacement (as plus = to the right or minus = to the left) in mm
ΔXL change of hinge axis at the left condyle in X-direction in mm
ΔZL change of hinge axis at the left condyle in Z-direction in mm
ΔH change of incisal pin height in mm
ΔW change of transverse position of the incisal pin in mm
ΔL change of anteroposterior position of the incisal pin in mm
γ rotation of the hinge axis between two positions in plus or minus degrees

These data were plotted to the standard EMPI sheet. All data were statistically analyzed by a two-factor analysis of variance. An interactive analysis was added to detect interaction between the results of reproducibility of different operators and repetitions of the single operator.

Results

All EMPI coordinate values were analyzed from all operators for all patients. A probability factor of $P = 0.5$ was used to determine significance. Any EMPI P factor value below .05 would be considered significant, meaning the RP → ICP positions would not be statistically reproducible. The P values for three different operators were: ΔXR = .8927; ΔZR = .6542; ΔXL = .4902; ΔZL = .3410; ΔY = .1530; ΔH = .2283; ΔW = .8948; ΔL = .3272; γ = .4623. The analysis concerning one operator making five recordings from one patient yielded no statistical significance: ΔXR = .9799; ΔZR = .7233; ΔXL = .9505; ΔZL = .9748; ΔY = .8229; ΔH = .2068; ΔW = .8312; ΔL = .4857; γ = .2900. The statistical interaction analysis was used to combine and intensify the influence of both procedures on reproducibility, ie, repetitions vs different operators. Interaction data refer to all operators and all patients. Again no significance was found: ΔXR = .6637; ΔZR = .9383; ΔXL = .9706; ΔZL = .9114; ΔY = .3445; ΔH = .3773; ΔW = .7485; ΔL = .5848; γ = .4770.

The X, Y, and Z values had mean standard deviations ranging up to 0.193 mm. ΔH, ΔW, and ΔL, positions of the articulator incisal pin calculated from X, Y, Z, and γ values, had mean standard deviations ranging up to 2.141 mm (ΔXR = 0.177 mm, ΔZR = 0.193 mm, ΔXL = 0.125 mm, ΔZL = 0.152 mm, ΔY = 0.056 mm, ΔH = 2.141 mm; ΔW = 0.275 mm, ΔL = 1.509 mm) and the mean standard deviation of γ was 0.917 degrees.

The values in X, Y, and Z ranged from 0.02 to 0.63 mm. The γ values ranged from 0.27 to 1.55 degrees. The incisal pin values (ΔH, ΔW, and ΔL) ranged from 0.02 to 3.54 mm. The translocation of the hinge axis, represented by ΔY, showed the greatest variability among the three operators ($P = .1530$). This variability was still above the $P = .05$ level, and the positions are considered reproducible. ΔY values of the single operator showed much less variability ($P = .8229$) when the procedure was repeated five times by one operator. The corresponding transverse coordinate, ΔW, measured anteriorly at the calculated position of the incisal pin, showed little variability and was of no statistical consequence regarding reproducibility. The values of ΔW from all three operators was 0.8948 mm, and for one operator, repeating the record five times, it was 0.8312 mm.

Discussion

The EMPI offers diagnostic advantages to the clinician beyond the scope of this article. Lateral and frontal head films taken at the ICP position can be converted to a reference or therapeutic position for analyses. Direct analyses at the lateral or medial poles of the condyles can be made by computer recalculations of the data based on actual intercondylar distances measured from a submentovertex radiograph. This recalculation eliminates the induced errors of skew and tilt when assessing measurements lateral to the condyles. Splint positions can be monitored to follow treatment plans. Positions from prosthetic reconstruction can be verified. Also, a differential diagnosis of the symptomatology from the dental physical can be related to various joint positions.

The results show that diagnostic positioning can be stated to be reproducible in symptomatic patients. The authors emphasize that this study is not meant to show that these positions are absolutely stable over time (weeks, months, years). This article is more a description of an occurrence stating that 15 symptomatic individuals offered the possibility of statistically reproducible joint positioning—even if it is contrary to the experience of some clinicians due to different techniques and instrumentation. Consequently, patients were not placed on splints for study purpose only.

The study was carried out in vivo only, not on mounted articulators with split cast verification, to

exclude errors induced by materials and mounting procedures. The study contained symptomatic patients only. Therefore, no comparison between the reproducibility of asymptomatic and symptomatic subjects can be made.

Hinge axis location and reference position or deranged reference position[14] were not inadequately reproducible at the time of examination of patients. Absolute reproducibility (over a long time) cannot be stated, as it has not been examined in this study. This indicates the need for further study to find out if there are unchanging, reproducible hinge axis and reference positions. Repositioning splints might be used for that purpose. High proprioception of the masticatory organ and adequate instruction by the therapist (to teach the patient how to move the mandible correctly for RP → ICP) may allow reproduction positions even in symptomatic patients.

The equipment used represents some aid for diagnosis and therapy. Reproducibility does not refer to equipment but to the coordinated cooperation of patient and therapist. Correct hinge axis location and reference position devolve on the therapist and patient and not only on the equipment. The average dentist can find a reproducible RP → ICP without use of special instrumentation (the equipment only quantifies). The advantage of EMPI is immediate quantification of movements.

None of the patients reproduced positions without any deviation, based upon the equipment's resolution of 0.01 mm. Statistical evaluation states reproducibility in this study within statistical views and limits. Deviations of a minority of subjects can be influenced by the statistics.

Pullinger[11] states that "Currently there is no consensus regarding the significance of mandibular condyle position in patients with TMJ disorders despite previous implications of an association."

Conclusion

The differences between the mean and standard deviations of all recordings were on average less than 0.2 mm from all operators and patients (referring to X, Y, and Z coordinates in ΔX, ΔY, and ΔZ).

The method of quantifying measurements of the movement of hinge axis reference position to the fixed hinge axis position at maximum intercuspation was demonstrated. The reproducibility of one examiner finding repeatable values for RP → ICP five times in one patient was also shown, as was the reproducibility amongst three different operators in finding RP → ICP values that compared to other operators. The results indicate statistically reproducible joint positioning in the RP → ICP mode.

The patients used in this research were from the TMJ clinic at the University of Vienna. In general, one may expect that asymptomatic patients exhibit less variability than symptomatic ones and that operators have less influence over them and, subsequently the recordings. This assumption is based on data from computerized axiography in which hinge axis tracings show instability at the hinge axis in symptomatic patients and not in asymptomatic patients. From this interpretation it is concluded that the EMPI is considered an appropriate method to analyze hinge axis phenomena. EMPI findings of RP → ICP should be considered for orthopedic diagnoses, treatment plans, and treatment verification in symptomatic patients since they have been reproducible.

The number of patients used was only 15; further studies with more patients are indicated to confirm or contradict the result of this study.

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Resumen

Reproducibilidad de las posiciones del eje de besagra condilar en paientes realizadas por diferentes operadores utilizando el indicador electrónico de posición mandibular

Todos y cada uno de los tres operadores que participaron en este estudio realizaron cinco registros en 15 pacientes sintomáticos con el indicador electrónico de posición mandibular. El método consistió en las mediciones bilaterales de cambios especiales del eje de bisagra recalculado por la compuadora a una destancia intercondilar de 110 mm y una tercera posición, calculada desde la rotación del eye de bisagra, en la tabla de la guía encisal. Todos los registros individuales de los pacientes fueron relacianados al origen del mismo sistema coordinado. Este origen fue designado y definido como la posición de referencia, con la eliminacion determinada de cualquier posición articular establecida para esta definición. Esta información demuestra que la reporducibilidad de las posiciones del eje de bisagra condilar, o sea las posiciones condilares del eje de bisagra condilar, o sea las posiciones de referencia a las posiciones condilares del eje de bisagra dictadas por la intercuspidación máxima de los dentes fue en promedio menos de 2/10 mm en cada registro de todos los operadores y pacientes.

Zusammenfassung

Reproduzierbarkeit der kondylären Scharnierachsposition bei Patienten anhand des Elektronischen Mandibular-Positions-Indikators von verschiedenen Behandlern

Drei verschiedene Untersucher machten an 15 symptomatischen Patienten 5 Aufzeichnungen mit dem Elecktronischen Mandibular-Positions-Indikators. Die Methode besteht in der Messung der beidseitigen räumlichen Verschiebung der Scharnierachse die vom Computer auf einen Interkondylarabstand von 110 mm berechnet wird, ferner in der Bestimmung einer dritten Position am inzisalen Führungsteller, die aus der Rotation um die Scharnierachse berechnet wird. Alle individuellen Aufzeichnungen am Patienten werden auf den Ursprung eines gemeinsamen Koordinatensystems bezogen. Dieser Ursprung wird als Referenzpunkt definiert ohne Bezug auf eine bestimmte Gelenkposition. Die Messungen erfolgten in allen Ebenen des Raumes in 10 Millimicron Inkrementen unter Einschluss der Rotation der Scharnierachse in Hunderstel Graden. Die Daten zeigten, daß die Reproduzierbarkeit der Scharnierachse für jede Aufzeichung von allen Behandlern und Patienten im Durchschnitt besser als 2/10 mm war.