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Gülcan Coşkun Akar[1], Adalet Erdem[1], Emel Ada[2], Timur Köse[3]

Usporedba kliničkih, instrumentalnih i slikovnih metoda u dijagnosticiranju temporomandibularnih poremećaja

Comparison of Clinical, Instrumental and Imaging Methods in Diagnosis of Temporomandibular Disorders

[1] Zavod za protetiku Stomatološkog fakulteta Sveučilišta Ege
Ege University, School of Dentistry, Department of Prosthodontics
[2] Zavod za radiologiju Medicinskog fakulteta Sveučilišta Dokuz Eylul
Dokuz Eylul University, Faculty of Medicine, Department of Radiology
[3] Zavod za radiologiju Medicinskog fakulteta Sveučilišta Ege
Ege University, Faculty of Medicine, Department of Radiology

Sažetak

Svrha: Osim kliničke procjene u ovom se radu željelo procijeniti i snimke kondilarnih kretnji dobivenih kompjutorskom aksiografijom u slučaju temporomandibularnih poremećaja kod zdravih osoba i dislokacije diska te prema njihovoj težini rangirane MR-snimke tragova dobivenih u drugim položajima zgloba. **Materijal i metode:** Analizirano je 18 slučajeva s mišićnim poremećajima (16 ženskih i 2 muška pacijenta prosječne dobi 32,06±15,99) i 11 pacijentica (prosječna dob 25,27±10,05) kod kojih su na pregledu magnetskom rezonancijom bili uočeni različiti stupnjevi intrakapsularnih poremećaja. U kontrolnoj skupini bilo je 6 žena te 4 muškarca prosječne dobi 22,20±2,39. Svi su bili na kompjutorskoj aksiografiji. Analizirane su i magnetske snimke pacijentata s intrakapsularnim poremećajima. Proučavani su i zvuk zgloba te raspon kretanja mandibule. Podaci su obrađeni statistički (Mann-Whitneyevim U testom, Student t-testom, One-way ANOVA-om i Chi-Squarom α=0,05). **Rezultati:** Razlike u kretnji otvaranja usta između (dviju) skupina s TMP-om i one kontrolne bile su neznatne (p=0,27). Kad je riječ o čeljusnim zglobovima, razlike između skupina s unutarnjim poremećajem i onih s mišićnim bile su također beznačajne (p=0,09). Kod asimptomatske kontrolne skupine duljina staze čeljusnih zglobova bila je uglavnom simetrična i normalnog raspona. Duljina staze kod skupine s mišićnim poremećajem bila je općenito slična onoj u kontrolnoj skupini, ali kretnje, kad su se ponavljale, nisu bile tako dobre kao kod kontrolne skupine. Duljine staze kod pacijenata s različitim stupnjevima poremećaja dijagnosticiranih magnetskom rezonancijom, bile su kraće od normalnih i bilo je odstupanja, pa i križanja puteva. **Zaključak:** Osim pažljivog kliničkog pregleda, koristile su se i dijagnostičke tehnike temeljene na promjeni funkcije te sustavi za analizu slika. Koštane strukture, posebice meka tkiva čeljusnih zglobova, mogu se pregledati magnetskom rezonancijom te se može ocijeniti njihov međusobni odnos. Kod metode koja daje podatke o funkcionalnom stanju zgloba, mogu se dobiti objektivni podaci te odrediti postupak liječenja.

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Adresa za dopisivanje
Dr. Gülcan Coşkun Akar
Ege University
School of Dentistry
Department of Prosthodontics
35100 Izmir, Turkey
gulcan.coskun.akar@ege.edu.tr

Ključne riječi
temporomandibularni poremećaji; čeljusni zglob; radiografija

Uvod

Temporomandibularni poremećaji (TMD) skupina su simptoma povezanih s bolovima u žvačnim mišićima, problemima čeljusnih zglobova ili njihovom kombinacijom. Glavni simptomi su: ograničen raspon kretanja mandibule, bol na palpaciju mišića ili na kretnje mandibule ili oboje te zvukovi u zglobu. Te se tegobe mogu pojaviti istodobno ili odvojeno, s prekidima ili, pak, mogu postati kronične (1). Unutarnji poremećaj čeljusnog zgloba opisuje se kao odstupanje od anatomskog položaja ili oblika tkiva unutar čahure zgloba (2). Primjer je dislokacija diska s redukcijom ili bez nje. Najčešći oblik je anteriorna dislokacija, tj. dislokacija prema naprijed, premda je opisana i posteriorna, tj. dislokacija diska prema natrag (3).

Danas se koristi nekoliko slikovnih metoda za procjenjivanje stanja čeljusnog zgloba, primjerice artrografija, kompjutorska tomografija i magnetska rezonancija (MRI). Čini se da se tom posljednjom najbolje određuje položaj diska čeljusnog zgloba, a osim toga omogućuje istodobni dvostrani vizualni prikaz obaju zglobova (4).

Uvid u dinamiku kondilarnih kretnji dobiva se uređajem koji bilježi kondilarne funkcije. Na taj je način moguće dobiti i dinamičke slike kondilarnog funkcioniranja (5). Kod standardnih aksiografskih pretraga istražuju se definirane mandibularne kretnje lijevog i desnog čeljusnog zgloba i to pomoću masivnog sustava dvostrukoga obraznog luka čvrsto pričvršćenoga na gornju i donju čeljust (6). Kompjutorizirana aksiografija može zabilježiti trodimenzionalne kretnje (3 D) donje čeljusti i ispisati njihove krivulje u vremenu, što omogućuje i procjenu brzine tijekom tih pokreta (7, 8). To je neinvazivna metoda koja omogućuje praćenje trodimenzionalne kretnje donje čeljusti, kako bi se kasnije u artikulator mogli prenijeti horizontalni kondilarni put i Bennettov kut (9).

Studije u kojima su se uspoređivali rezultati zabilježenih kondilarnih kretnja s rezultatima dobivenima kliničkim ispitivanjem uz pomoć magnetske rezonancije ili artroskopije, navode na različite zaključke. To može biti i zbog problema kod interpretacije rezultata slikovnih metoda i/ili tehničkih poteškoća tijekom bilježenja kondilarnih kretnja. Osim kliničke procjene, željelo se komparativno ocijeniti prikaz kondilarnih kretnji dobivenih kompjutorskom aksiografijom kod ispitanika s temporomandibularnim poremećajima (mišićnim poremećajima, dislokacijama diska i drugim patološkim stanjima zgloba) i kod zdravih osoba te dislokacije diska dobivene u drugim položajima zgloba.

Introduction

Temporomandibular disorders (TMD) are symptoms related with masticatory muscle pain, problems of the temporomandibular joint (TMJ) and its associated structures, or combinations of both. Main symptoms are: limited mandibular range of motion, pain on muscle palpation or mandibular movements or both, and joint sounds. These problems may occur simultaneously, separately, intermittantly, or may become chronic (1). The internal derangement of TMJ is described as a deviation in the anatomical position or form of the tissues within the capsule of the joint (2). Disc displacements with or without reduction within the TMJ are examples of frequently occurring internal derangements. Anterior disc displacement (ADD) – disc displacement in an anterior direction – is the most common type of disc displacement although posterior disc displacement (PDD) has also been described (3).

Currently there are several imaging methods to evaluate the TMJ, such as arthrography, computer tomography and magnetic resonance imaging (MRI). MRI seems to be the method of choice for determining TMJ disc position and it also allows the simultaneous bilateral visualization of both joints (4).

Condylar recording devices provide a dynamic impression of condylar function. It is also possible to obtain dynamic images of condylar functioning (5). During conventional axiographic investigations, tracing of defined mandibular movements are recorded for both right and left temporomandibular joints by means of a bulky double facebow system which is rigidly attached to the maxilla and mandible (6). Computerized axiography is a software that can record three dimensional (3D) mandibular movements and create their time related curves which enable the assessment of velocity during movement as well (7, 8). It is a non-invasive method allowing 3D mandibular movement recordings for transferring horizontal condylar path and Bennett angle to the articulator (9).

Studies that have compared the results of condylar movement traces with those of a clinical examination by means of MRI or arthroscopy have come to different conclusions. This may be a result of problems encountered in the interpretation of the imaging results and/or technical problems with the recording of condylar movements. In addition to the clinical evaluation, it was aimed to comparatively assess the traces obtained by computerized axiography of the condylar movements in temporomandibular disorders (muscle disorders, disc dis-

placements, and other joint conditions) in healthy individuals together with disc displacements and staged MRI images of these traces obtained in other joint positions.

Metode

Ispitanici

U studiji je obrađeno osamnaest slučajeva sa sindromom miofacijalne boli (16 žena i 2 muškarca, prosječna dob 32,6±15,99) i jedanaest slučajeva (sve žene, prosječna dob 25,27 ±10,05) kod kojih su na magnetskoj rezonanciji uočeni intrakapsularni poremećaji u različitim stadijima, a svi su se obratili Odjelu za protetiku Stomatološkog fakulteta Sveučilišta Ege. Pacijente je pregledao stomatolog i njihova je anamneza zabilježena u skladu s kliničko-istraživačkim kriterijima za temporomandibularne poremećaje (RDC/TMD) (18).

Kontrolnu skupinu činilo je deset osoba (6 žena i 4 muškarca, prosječna dob 22,20 ±239) - zdravih, eugnata, Angle klasa I, bez parodontskih problema i kraniofacijalnih ozljeda ili operacija te temporomandibularnih poteškoća i bez ranijih ili aktualnih ortodontskih zahvata.

Svi su dali pristanak za sudjelovanje u istraživanju.

Klinička pretraga

Za dijagnosticiranje i kategorizaciju pacijenata s temporomandibuilarnim poremećajima koristili su se kliničko-istraživački kriteriji za takvu vrstu poremećaja (*engl*. Research Diagnostic Criteria for Temporomandibular Disorders - RDC/TMD) (10). Tako opisane kliničke pretrage uključuju procjenu simptoma temporomandibularnih poremećaja, kao što su (a) mjesto bola, (b) raspon kretanja mandibule i bol što se pritom javlja, (c) zvukove unutar čeljusnih zglobova i (d) palpaciju ili osjetljivost mišića i zglobova. Kategorizacija RDC/TMD-a pokriva tri najčešće dijagnostičke kategorije ili skupine (mišićni poremećaji, dislokacija diska te drugi poremećaji zgloba - artralgija, osteoartritis i osteoartroza). Kako je bilo malo ispitanika s dislokacijom diska i drugim problemima, te su dvije skupine udružene za statističku analizu te ocijenjene pod nazivom "skupina s dislokacijom diska". Podaci magnetske rezonancije i kompjutorske aksiografije uzeti su prema gore navedenim trima skupinama. Pacijenti s dislokacijom diska u određenim položajima, upućeni su na snimanje magnetskom rezonancijom.

Jedan je liječnik pregledao pacijente stetoskopom. Tehnika se sastojala od prislanjanja slušalice

Material and Methods

Participants

18 cases with myofacial pain syndrome (16 women and 2 men with mean ages 32.06±15.99) and 11 cases (11 women, mean age 25.27 ±10.05) observed to have intraarticular disorders at different stages as a result of MRI evaluation, who referred to Ege University, School of Dentistry, Department of Prosthodontics, were included in the study. The patients were visited by a dentist and their clinical history was recorded according to RDC/TMD (18).

The control group consisted of 10 (6 women and 4 men with mean ages; 22.20 ±2.39) healthy, dentate and orthodontic Angle Class I subjects with no parodontal problems, no craniofacial trauma or surgery, no temporomandibular or craniocervical disorders, and no previous or current orthodontic treatment.

Informed patient consents were taken from all subjects participating in the study.

Clinical examination

Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) were used for diagnosing and classifying TMD patients (10). The RDC/TMD clinical examination involves clinical assessment of TMD signs and symptoms including (a) pain site, (b) mandibular range of motion and associated pain, (c) TMJ sounds, and (d) muscles and joint palpation or tenderness. The RDC/TMD groups the most common forms of TMD into 3 diagnostic categories or groups (muscle disorders, disc displacements, and other joint conditions [arthralgia, osteoarthritis, and osteoarthrosis]). Since the number of patients with disc displacement and other joint conditions was few, these two groups were combined for statistical analysis and evaluated as disc displacement group. Data for MRI and computerized axiography were taken according to above mentioned 3 groups. Patients exhibiting disc displacement of determination of disc position were directed for magnetic resonance imaging (MRI).

One examiner examined patients by means of auscultation with a stethoscope. As for the technique, the bell of an infant stethoscope (3M Litt-

stetoskopa za djecu (3M Littmann) na lateralni pol čeljusnoga zgloba, kako bi se otkrili zvukovi.

Raspon kretnji mandibule ispitivan je tijekom maksimalnog otvaranja usta i lateralnih kretnji. Otvaranje se mjerilo u milimetrima od središnjega maksilarnog inciziva do njemu suprotnog mandibularnog. Lateralne kretnje bile su određene u odnosu prema maksilanoj središnjoj crti, s lagano razdvojenim zubima.

Magnetska rezonancija

Snimke magnetske rezonancije (uređaj Philips Intera 1,5 T MR, Nizozemska) očitavao je uvijek isti specijalist. Za sagitalne kose snimke sa zatvorenim ustima i u poziciji maksimalno otvorenih usta, te za koronarne kose snimke, primijenjeni su sljedeći parametri: za T1; TR:1500 ms, TE:30 ms, vidno polje:150 mm, debljina reza: 3 mm, 240X256, za T2; TR=5835 msec, TE=110 ms, TSE môd.

Procjena slučajeva prema MR-snimkama obavljena je prema stadijima koje je definirao Vogl (11):

Stadij I.**:** anteriorna/posteriorna dislokacija diska s redukcijom;

Stadij II.**:** dislokacija diska s deformacijom;

Stadij III.**:** dislokacija diska bez redukcije s deformacijom;

Stadij IV.: osteoartroza i teška deformacija diska;

Stadij V.: ruptura diska, teške degenerativne promjene na kostima;

Stadij VI.: resorpcija diska, avaskularna nekroza, osteohondroza.

Bilježenje postupkom kompjutorizirane aksiografije

Kako bi se zabilježile kondilarne kretnje obaju čeljusnih zglobova tijekom kretnji donje čeljusti korišten je software za elektroničku aksiografiju (Denar® Cadiax Compact, Gamma Dental Software® verzija 2,3 za operacijski sustav Windows, Klosterneuburg, Austrija) koji sadržava principe i ciljeve temeljne elektroničke aksiografske procjene/evaluacije (12-15).

Za snimanje određenih kretnji donje čeljusti korišten je rigidni sustav dvostrukoga obraznog luka za oba čeljusna zgloba, uporabom aksiografa marke Cadiax (8).

Statistička analiza

Za statističku analizu podataka rabio se software SPSS 11,0 za operacijski sustav Windows (1999 SPSS Inc., Chicago IL, USA). Za komparativnu analizu

mann) was placed over the lateral pole of the TMJ for TMJ sounds.

Mandibular range of motion was evaluated for maximum opening and lateral movements. Maximum opening was measured from central maxillary incizor to the opposing mandibular incizor on a millimetre ruler. Lateral movements were measured relative to the maxillary midline with the teeth slightly separated.

Magnetic resonance imaging

MRI (Philips Intera 1.5 T MR, Holland) scans were interpreted by a single investigator. The following parameters were used for sagittal-oblique images in the closed-mouth and maximal open-mouth positions and for coronal-oblique images in the closed-mouth position: For the T1; TR:1500 msec, TE:30 msec, field of view:150 mm, slice thickness: 3 mm, voxel matrix: 240X256, for T2; TR=5835 msec, TE=110 msec, TSE mode was selected.

The MRI assessments of the cases were made by the phases defined by Vogl (11).

Stage I: Anterior/posterior disk displacement, reducible;

Stage II: Disk displacement, reducible, with deformation;

Stage III: Disk displacement, irreducible, with deformation;

Stage IV: Osteoarthrosis and severe disc deformation;

Stage V: Disc rupture/perforation, severe osseous degenerative changes;

Stage VI: Disc resorption, avascular necrosis, osteochondritis dissecans).

Computerized axiography recording

For the recording of condylar movements of both TMJs during mandibular movements, an electronic axiography (Denar® Cadiax Compact, Gamma Dental Software® Version 2.3 for Windows, Klosterneuburg, Austria) software which included the principles and objectives of basic electronic axiographic evaluation was used (12-15).

The tracings of determined mandibular movements were recorded by a rigid, double arch facebow system for both TMJs using Cadiax axiograph (8).

Statistical Analysis

SPSS 11.0 for Windows (1999 SPSS Inc., Chicago, IL, USA) software was used for the statistical analyses of the obtained data. Chi Square was used

"prisutnih" i "odsutnih" tipova parametara među skupinama korišten je χ^2 test. Za usporedbu izmjerenih vrijednostî uporabljeni su testovi Mann-Whitneyjev-U test i t-test za analizu odstupanja (ANOVA). Razina znatnosti u svim testovima iznosila je 0,05.

Rezultati

Kliničke pretrage

Analizirajući vrijednosti za maksimalno otvorena usta kod svih triju skupina u milimetrima, dobiveno je 37,94 (±9,22) za mišićne poremećaje, 37,45 (±7,52) za dislokaciju diska i 42,90 (±7,68) u kontrolnoj skupini.

Za lateralne kretnje, kod svih triju skupina, u milimetrima je dobiveno 7,89 (±2,24) za mišićne poremećaje, 8,18 (±3,65) za dislokaciju diska i 10,1 (±2,02) u kontrolnoj skupini.

Razlike među slučajevima s intrakapsularnim poremećajem i miofacijalnom boli te kontrolne skupine, kad je riječ o veličini maksimalnog otvaranja usta, bile su statistički neznatne (p=0,27).

U vezi s lateralnim kretnjama, razlike između slučajeva s unutarnjim poremećajem i kontrolne skupine (U= 23,00; Z= -2,29; p=0,02) te razlike između slučajeva s miofascijalnom boli i kontrolne skupine (U= 45,5; Z= -2,16; p=0,3) bile su statistički velike, a razlike između slučajeva s unutarnjim poremećajem i onih s miofacijalnom boli bile su statistički beznačajne (p=0,67).

I na kraju, razlike između slučajeva s unutarnjim poremećajem i onih s miofacijalnom boli, a u vezi sa zvukovima iz čeljusnoga zgloba, bile su statistički neznatne (p=0,09).

Snimke metodom magnetske rezonancije

Stupnjevi poremećaja za oba čeljusna zgloba prema rezultatima MR-snimanja za jedanaest pacijenata s dislokacijom diska, ili s nekim drugim poremećajem zgloba, prikazani su na Tablici 1. MR-snimke za otvoreni i zatvoreni položaj usta za pojedine stadije mogu se vidjeti na slikama 3a-b, 4a-b, 5a-b.

Bilježenje metodom kompjutorske aksiografije

Duljina zabilježenog puta čeljusnih zglobova kod asimptomatske kontrolne skupine općenito je simetrična i u normalnom rasponu. Nije bilo odstupanja od tragova ili križanja (Slika 1. a-b). Samo kod dvojice pacijenata tragovi su bili ispod normalnog raspona. Kod analize Bennettovih kretnja, zapažena je simetrija zahvaljujući harmoničnoj kretnji obaju čeljusnih zglobova tijekom pomicanja/kretanja osi kod asimptomatske skupine ispitanika. Simetrija je rijetko bila narušena. No, bilo ju je teško

for comparative analyses of `present` or `absent` type parameter among the groups. For the comparisons of metric measurements, Mann Whitney-U, t test or analysis of variance (ANOVA) tests were used. The level of significance for all tests was 0.05.

Results

Clinical Examination

Evaluating the maximum mouth opening values of the three groups in mm, the values of 37.94 (±9.22) were observed for muscle disorders; 37.45 (±7.52) for disc displacement; and 42.90 (±7.68) for control.

As for the evaluation of lateral movements of the three groups in mm, the values of 7.89 (±2.24) were observed for muscle disorders; 8.18 (±3.65) for disc displacement; and 10.1 (±2.02) for the control.

The differences among the cases with internal derangement, myofascial pain and the control groups as regards the amount of mouth opening movement were insignificant (p=0.27).

In terms of lateral movement, the differences between internal derangement cases and the control group (U= 23.00; Z= -2.29; p=0.02), and the differences between myofascial pain and the control groups (U= 45.5; Z= -2.16; p=0.03) were significant. The differences between internal derangement and myofascial pain groups were insignificant. (p=0.67).

The differences between the internal derangement and myofascial pain groups regarding TMJ sounds were insignificant (p=0.09).

Magnetic resonance imaging

The stages of disorders for both TMJs according to the MRI results obtained from 11 patients with disc displacement or other joint conditions have been listed in Table 1. Open and closed MRI images relating to different stages can be seen in Figs. 3 a-b, 4 a-b, 5 a-b.

Computerized axiography recording

The length of the tracings of asymptomatic control group TMJs were generally symmetrical and in normal range. There were no deviations from the tracings or crossings (Fig. 1a-b). Only in 2 patients the tracings were under normal range. As for the evaluation of Bennett movements, symmetry was observed due to harmonious movement of both TMJs during axis movement in the asymptomatic control group subjects. The symmetry was deteriorated in a few cases, however, it was hard to evaluate,

Slučaj • Case	Desni • Right TMJ	Lijevi • Left TMJ
1	5	4
2	2	0
3	0	5
4	4	4
5	2	2
6	5	5
7	2	2
8	2	2
9	2	4
10	4	4
11	4	4

Tablica 1. Snimke metodom magnetske rezonancije za oba zgloba
Table 1 MRI findings for both TMJs

(pr)ocijeniti, čak i vizualno (Slika 1.a). Osim simetrije, opažena je i harmoničnost u pomicanju osi. Nisu uočene nikakve iznenadne akceleracije ili deceleracije (Slika 1.b).

Zabilježene kretnje kod skupine pacijenata s miofacijalnom boli bile su općenito slične onima kod kontrolne skupine, no u slučaju ponavljanja nisu bile tako dobre kao kod kontrolne skupine. Tragovi su bili kraći zbog ograničenosti otvaranja usta i lateralnih kretnja. Inkurzivni i ekskurzivni tragovi nisu se preklapali, niti su odstupali, te nisu zapažena nikakva preklapanja (Slika 2. a-b). Kod procjene Bennettovih kretnja, uočena je - zbog bolesti zahvaćenih mišića - zakašnjela kretnja i gubitak simetrije na bolesnoj strani, za razliku od one suprotne. Nije bilo nikakvih iznenadnih akceleracija ili deceleracija (Slika 2.a-b).

Prema dijagnozi ustanovljenoj magnetskom razonancijom, tragovi kod pacijenata u II.stadiju bili su u normalnom rasponu. Uočena su velika odstupanja, ali ne i križanja (Slika 3.c).

Tragovi kod pacijenata u IV. stadiju bili su znatno kraći od normalnih, ipak u nekim slučajevima bliže normalnima. Uočena su velika odstupanja putanja u svim slučajevima, a križanja u nekima (Slika 4.c).

Tragovi kod pacijenata u V. stadiju bili su znatno kraći od normalnih. Uočena su velika odstupanja na putanjama, inverzije i križanja (Slika 5.c).

Proučavajući Bennettove kretnje u slučajevima dislokacije diska i drugih poremećaja zgloba, uočeni su različiti oblici kretnja čeljusnih zglobova, uvjetovani stupnjem poremećaja, promjenom kretanja osi u vezi s dužinom kretnje te gubitkom simetrije. Bilo je i iznenadnih akceleracija i deceleracija, zbog križanja te većih devijacija putanja (Slike 4.c, 5.c).

even visually (Fig. 1 a). Besides symmetry, a harmony was also observed for the axis movements. No instantaneous accelerations or decelerations were observed (Fig. 1 b).

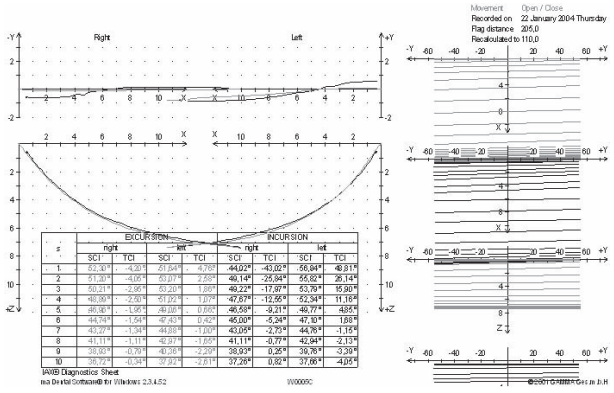
The tracings of the myofascial pain group patients were generally similar to those of the control group, however, the reproducibility of the movement was not as good as that in the control group. The tracings were shorter due to limitations in mouth opening and lateral movements. The incursive and excursive tracings did not coincide or deviate, and no crossings were observed (Fig. 2a-b). As for the evaluation of the Bennett movements, due to the affected muscles, delayed movement and loss of symmetry were observed on the affected side as compared to the contralateral one. No instantaneous accelerations or decelerations were observed (Fig. 2a-b).

As diagnosed by MRI, the tracings of *Stage II* patients were in normal range. Severe deviations were observed on their pathways, however, no crossings were observed (Fig 3 c).

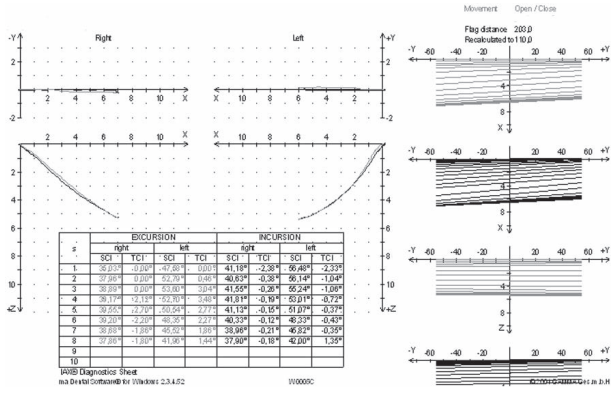
As diagnosed by MRI, the tracings of some *Stage IV* patients were much shorter than normal, while in some cases they were closer to normal. Severe deviations on pathways in all cases, and crossings in some, were observed (Fig 4c).

As diagnosed by MRI, the tracings of *Stage V* patients were much shorter than normal. Severe deviations on pathways, inversions and crossings were observed. Only in 1 patient neither inversions nor crossings were observed (Fig 5c).

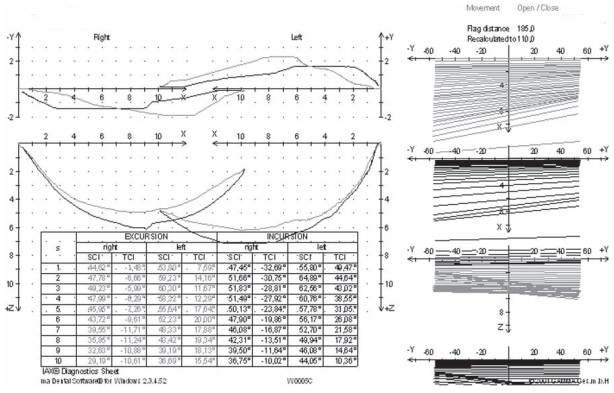
Evaluating the Bennett movements in disc displacement and other joint conditions cases, different TMJ movements due to the stage of the derangement, changing of the axis movement length related with the length of the movement, as well as loss of symmetry were observed. Instantaneous accelerations and decelerations due to crossings, and severe deviations on the tracings were observed (Figs. 4c-5c).



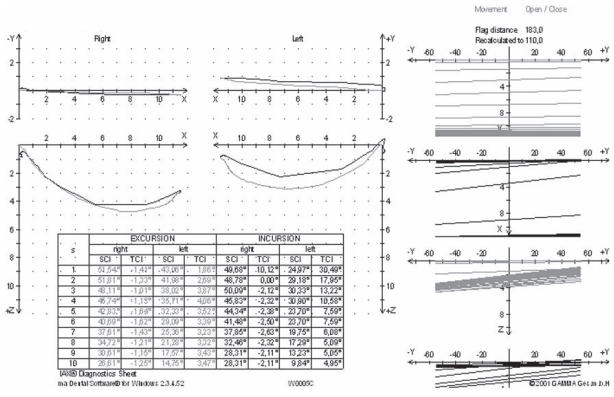
Slika 1a. Aksiografsko praćenje pokreta otvaranja-zatvaranja u zdravog ispitanika
Figure 1a Axiographic tracings of opening-closing movement of a healthy case



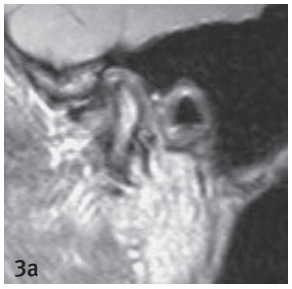
Slika 1b. Aksiografsko praćenje pokreta otvaranja-zatvaranja u drugog zdravog ispitanika
Figure 1b Axiographic tracings of opening-closing movement of another healthy case

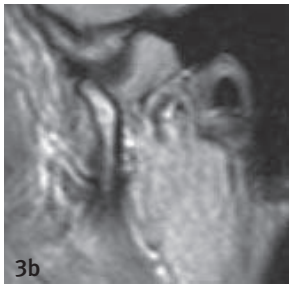


Slika 2a. Aksiografsko praćenje pokreta otvaranja-zatvaranja u ispitanika s mišićnim poremećajem
Figure 2a Axiographic tracings of opening-closing movement of a muscle disorder case



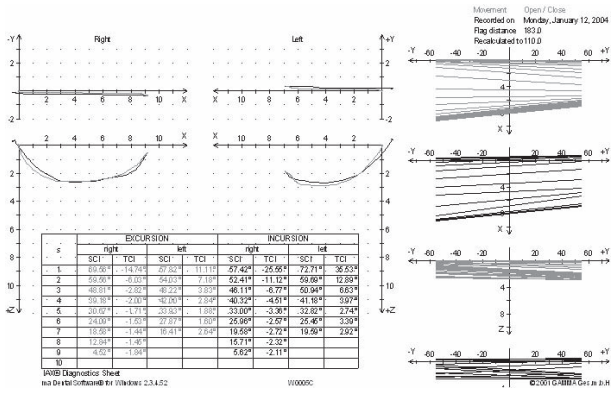
Slika 2b. Aksiografsko praćenje pokreta otvaranja-zatvaranja u drugog ispitanika s mišićnim poremećajem
Figure 2b Axiographic tracings of opening-closing movement of another muscle disorder case



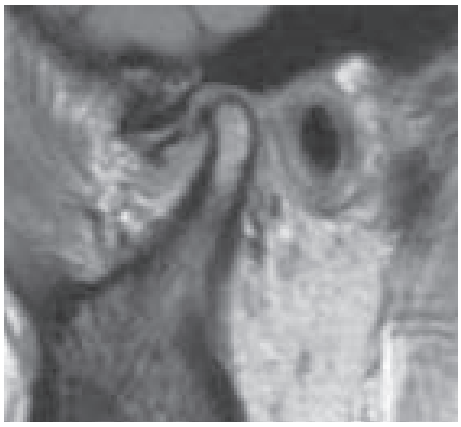


Slika 3a. Magnetska rezonancija zatvorenog zgloba s poremećajem 2. stupnja
Figure 3a Closed MRI of stage 2 joint

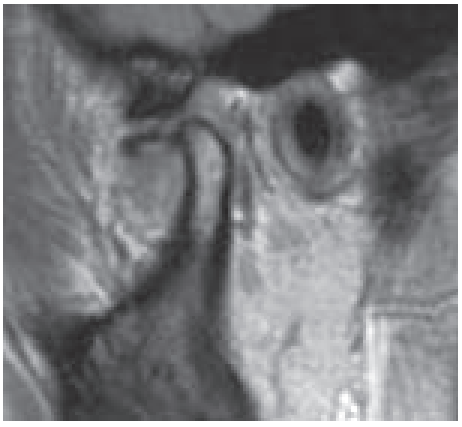
Slika 3b. Magnetska rezonancija otvorenog zgloba s poremećajem 2. stupnja
Figure 3b Open MRI of stage 2 joint



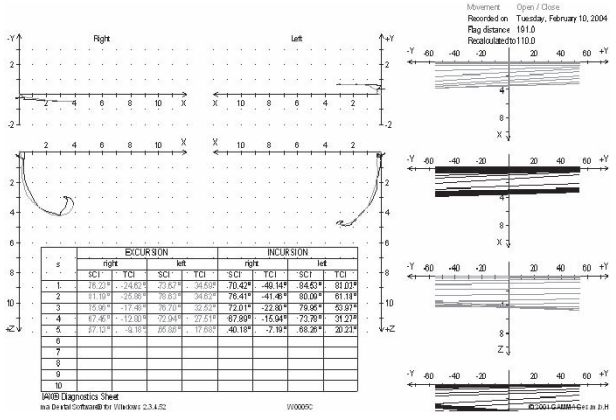
Slika 3c. Aksiografsko praćenje pokreta otvaranja-zatvaranja u slučaju obostranog poremećaja 2. stupnja
Figure 3c Axiographic tracings of opening-closing movement of a Right-Left stage 2 case



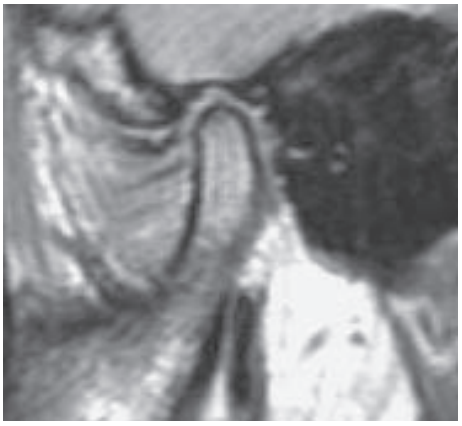
Slika 4a. Magnetska rezonancija zatvorenog zgloba s poremećajem 4. stupnja
Figure 4a Closed MRI of stage 4 joint



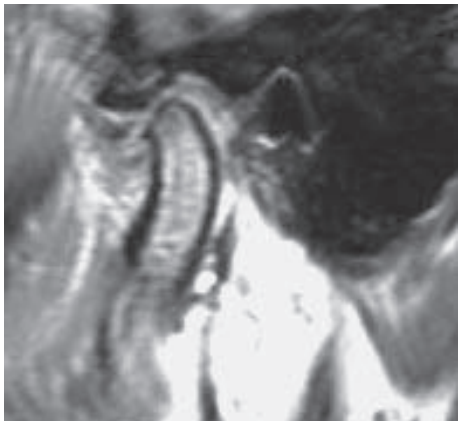
Slika 4b. Magnetska rezonancija otvorenog zgloba s poremećajem 4. stupnja
Figure 4b Open MRI of stage 4 joint



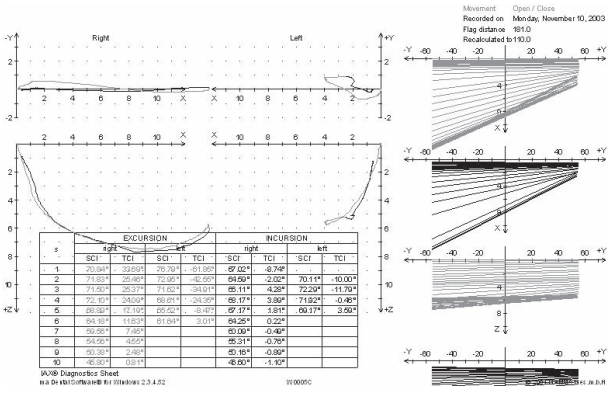
Slika 4c. Aksiografsko praćenje pokreta otvaranja-zatvaranja u slučaju obostranog poremećaja 4. stupnja
Figure 4c Axiographic tracings of opening-closing movement of a Right-Left stage 4 case



Slika 5a. Magnetska rezonancija zatvorenog zgloba s poremećajem 5. stupnja
Figure 5a Closed MRI of stage 5 joint



Slika 5b. Magnetska rezonancija otvorenog zgloba s poremećajem 5. stupnja
Figure 5b Open MRI of stage 5 joint



Slika 5c. Aksiografsko praćenje pokreta otvaranja-zatvaranja zdravog desnog i poremećenog lijevog (5. stupanj) zgloba
Figure 5c Axiographic tracings of opening-closing movement of a Right healthy and Left stage 5 case

Rasprava

Bilježenje kretnji sa šest stupnjeva slobode pokazalo je velike mogućnosti u proučavanju trodimenzionalnog/ih kretanja/nja mandibule (5). Sada je moguća rekonstrukcija puta kretnji od bilo koje točke mandibule u odnosu prema lubanji (16). Kretnje vođene zubima, kao primjerice, protruzija i mediotruzija, pokazale su veliku varijabilnost, a za dijagnostičke svrhe preporučuje se ciklus otvaranja i zatvaranja. Smatralo se da su čeljusni zglobovi normalni ako aksiografija pokazuje konkavan put dužine 9 mm ili više (17). Rozenzweig i suradnici (18) definirali su normalan čeljusni zglob identičnim eks- i inkurzivnim putevima na prvih pet milimetara bez naglih/oštrih promjena smjera. U toj studiji, u kojoj su se tragovi kretnja otvaranja/zatvaranja koristili za dijagnostiku i usporedbu s nalazima magnetske rezonancije, kod asimptomatskih zglobova ti su tragovi bili skladni, s tek nekoliko desetinkî milimetara razmaka i nisu pokazivali križanje. Ti su nalazi u skladu s onima Yatabea i suradnika (19) te Monenburga i Pröschela (20).

Križanje tragova otvaranja i zatvaranja ili znatni razmak između njih mogu upućivati na dislokaciju diska. U zglobu u kojem je nastala anteriorna dislokacija diska (ADD), odnos kondila/disk mijenja se u trenutku škljocanja (13, 21, 22). Studije Huddlestona, Slatera i njegovih kolega (16) temelje se dijelom na odstupanjima od funkcionalne anatomije čeljusnih zglobova s unutarnjim poremećajem i predstavljaju daljnju razradu kriterija što su ih predložili Ozawa i Tanne (13)*,* Mauderli i suradnici (23) te Parlett i suradnici (9). ADD s redukcijom dijagnosticira se kao nagla promjena smjera s deceleracijama koja završava inverzijom između inkurzivnog i ekskurzivnog puta barem u jednoj projekciji. ADD bez redukcije povezuje se s gubitkom konkavnosti u sagitalnoj projekciji i dužinom krivulje manjom od 4 do 5 mm (9). U ovoj studiji nije uočena promjena odnosa kondil/disk u trenutku škljocanja (Slika 3.c) ni u jednom slučaju dijagnosticiranom kao ADD s redukcijom, bilo da se radilo o magnetskoj rezonanciji ili o kliničkom promatranju. U slučajevima ADD-a bez redukcije, a u skladu s nalazima Parletta i suradnika (9), kratkoća i konkavnost kod tragova kretnje otvaranja usta smatrale su se znakom ograničenja.

U literaturi se kompjutorski aksiografski nalazi mogu naći samo za slučajeve s dislokacijom diska i druge poremećaje zgloba. U ovoj studiji, premda su registracije dobivene u slučajevima s mišićnim poremećajima općenito pokazivale sličnost s onima u

Discussion

Movement recordings made with 6 degrees of freedom have shown great potential for the study of the 3-dimensional mandibular motion (5). They enable the reconstruction of the movement traces of any point of the mandible relative to the skull (16). Teeth guided movements like protrusion and mediotrusion demonstrated a greater variability, the opening/closing cycle is recommended for diagnostic purposes. Normal TMJs were diagnosed if the axiography presented a concave path with a length of nine mm or more (17). Rozenzweig et al. (18) characterized normal TMJ by identical ex- and incursive paths on first five mm without abrupt changes in direction. In this study where opening/closing movement traces were utilized for diagnostics and comparisons with MRI, in asymptomatic joints, opening and closing movement traces were smooth, just a few tenths of a millimeter apart, and showed no crossings. These findings are in accordance with those of Yatabe et al. (19) and Moneburg and Pröschel (20).

The crossing of, or a substantial distance between, opening and closing traces may indicate a disc displacement. In a joint with an anterior disc displacement, the condyle/disc relationship changes at the time of clicking (13, 21, 22). Huddleston Slater et al.'s studies (16) are based partly upon inferences from the functional anatomy of TMJs with an internal derangement, and are also an elaboration of criteria suggested by Ozawa and Tanne (13)*,* Mauderli et al. (23), and Parlett et al. (9). ADD with reduction was diagnosed as an abrupt change in direction (with decelerations) leading to an inversion integral between in- and excursive path in at least one projection. ADD without reduction was combined with an absence of concavity (in sagittal projection) and a curve length below four to five mm (9). In our study, the condyle/disc relationship changes at the time of clicking (Fig. 3c) were not observed in any cases diagnosed as ADD with reduction by means of MRI and clinical evaluation. In the cases of ADD without reduction, in accordance with the findings of Parlett et al. (9), the presence of shortness and concavity in the traces in the mouth opening movement was observed as a sign of limitation.

In literature, computerized axiography findings of only the cases with disc displacements and other joint conditions have been encountered. In our study, although the traces obtained from the cases with muscle disorders generally exhibited similarity with those obtained from the control group, the

kontrolnoj skupini, ponavljanje kretnji nije bilo tako dobro kao u kontrolnoj skupini. Dužina putanje bila je kraća nego što je normalno, a zbog ograničenja u otvaranju usta i tijekom lateralnih kretnja. No, ta je dužina tragova bila veća negoli kod slučajeva s teškim intrakapsularnim poremećajima. Inkurzivni i ekskurzivni tragovi nisu slijedili iste puteve i uočena su odstupanja, no nije bilo križanja. Premda se u sadašnjoj fazi ne mogu postupkom kompjutorske aksiografije razviti standardni tragovi i modeli slučajeva, autori studije mišljenja su da bi oni uzeti zajedno s detaljnom kliničkom procjenom pomogli u kontroli dijagnoze i omogućili ocjenu uspješnosti liječenja tako što bi se arhivirali dobiveni podaci.

Nalaz magnetske rezonancije na osnovi anatomske procjene položaja i oblika tkiva unutar čeljusnih zglobova, sugerira sasvim drugačije zaključke negoli metode temeljene na njihovim funkcionalnim karakteristikama (16). MR dijagnoza dislokacije diska u zglobu kod kojega nema funkcionalnih poremećaja, poznat je problem (24, 25, 26). U ovoj studiji raščlanjeni su položaj diska i njegov odnos prema koštanim strukturama, a dobiveni su podaci za oba zgloba. Zato se položaj redukcije i deformacije diska u pozicijama otvaranja i zatvaranja usta procjenjivao za svaki zglob posebno. Tako se dobila mogućnost usporedbe MR-snimki i nalaza nakon kliničkih promatranja i kompjutorske aksiografije.

U studiji o točnosti kliničkog promatranja, aksiografije, artrografije i magnetske rezonancije u otkrivanju unutarnjih poremećaja u čeljusnim zglobovima, Romanelli i suradnici (27) smatraju aksiografske uređaje točnim/preciznim sredstvom za otkrivanje unutarnjih poremećaja. Parlett i suradnici (9) te Ozawa i Tanne (13) usporedili su rezultate aksiografskih zapisa s MR-nalazima. Zaključili su da je aksiografija usputno djelotvorna u prepoznavanju bolesti kad je ona već prisutna. Prema stajalištima tih autora, aksiografija nije dovoljno točna da bi se dijagnosticiralo stanje čeljusnog zgloba, posebice u slučajevima kroničnog i/ili adaptivnog poremećaja. Prema nalazima magnetske rezonancije nije utvrđena podudarnost između očitanja kompjutorskom aksiografijom na zglobovima s istim stupnjem poremećaja. Zato, a u skladu s rezultatima Mauderlija i suradnika, autori ove studije vjeruju da se ne može postaviti dijagnoza samo na temelju kompjutorske aksiografije. Dosta je teško odrediti skupinu i stadij unutarzglobnog poremećaja primjenom samo te metode. I dok je aksiografskim očitavanjima moguće razlikovati slučajeve temporomandibularnog poremećaja kao mišićne intrakapsularne poremećaje,

reproducibility of the movement was not as good as that in the control group. The length of the tracings was recorded to be shorter than normal due to limitations in mouth opening and lateral movements. However, the length of the tracings was observed to be longer than those of the cases with severe intraarticular disorders. The incursive and excursive tracings did not follow the same pathways and deviations were observed, while no crossings were encountered. Although standard traces and models about the cases at this stage could not be developed with computerized axiography, the authors of this study are of the opinion that the tracings taken along with a detailed clinical evaluation would assist diagnosis control, and enable the evaluation of the treatment success through filing of the obtained data.

MRI based upon the anatomical evaluation of the position and form of the tissues within the TMJ comes to quite different conclusions than the methods based upon the functional characteristics of the TMJ (16). Diagnosis by MRI of disc displacements in joint with no functional disturbances whatsoever is a known problem (24, 25, 26). In this study, the position of the disc and its relation with the bony structures were evaluated and data relating to both joints were obtained. Hence, the reduction position and deformation of the disc in mouth opening and closing positions were evaluated for both joints separately. The opportunity of comparing MRI images with findings obtained from clinical evaluation and computerized axiography was achieved.

Romanelli et al. (27) in a study of the accuracy of clinical examination, axiography, arthrography and MRI in detecting internal derangements in the TMJ, considered axiographic devices to be an accurate means of detecting internal derangements. Parlett et al. (9) and Ozawa and Tanne (13) compared the results of axiographic recordings with those of MRI findings. They concluded that axiography is marginally effective in identifying disease when it is present. According to these authors, axiography is not accurate enough to diagnose a TMJ condition, especially in case of a chronic and/or adaptive derangement. According to MRI method, no consistency was determined between the computerized axiographic recordings obtained from joints with the same stage of disorder. Therefore, in compliance with the results of Mauderli et al.'s studies, it is believed by the authors of this study that diagnosis could not be reached by utilizing only computerized axiography recordings. It is rather difficult to determine the intraarticular disorder group and

u ovoj studiji nisu bili utvrđeni nikakvi jasni modeli aksiografskih očitanja koji bi definirali stadij unutarzglobnih poremećaja ni prema položaju diska, ni prema degeneraciji tkiva.

Za mnoge "standardne" slučajeve temporomandibularnih poremećaja bit će dovoljne (i) jednostavnije dijagnostičke metode, ali u nekima težima trebat će i dodatne informacije (28). Kompjutorska aksiografija i magnetska rezonancija mogu se koristiti istodobno, kako bi se poboljšala točnost pozitivne i diferencijalne dijagnoze (29). U skladu s jednom našom ranijinom studijom, mi smo se u pripremi ove studije koristili i kompjutorskom aksiografijom i magnetskom rezonancijom.

Teme koje zahtijevaju daljnje proučavanje, jer nisu bile potpuno istražene u ovoj studiji nakon što su analizirana očitanja kompjutorske aksiografije na zdravim ispitanicima i slučajevima s temporomandibularnim poremećajima, mogu se sažeto navesti kao dijagnostički kriteriji za očitanja kompjutorskom aksiografijom kod slučajeva s mišićnim poremećajim, a mogu se razviti proučavanjem još više slučajeva negoli kod temporomandibularnih poremećaja; kad je riječ o dislokaciji diska i drugim poremećajima/smetnjama zgloba, dijagostički indeks može se razviti raščlanjivanjem podataka magnetske rezonancije i očitanja kompjutorske aksiografije.

Zaključak

Iz ove studije mogu se izvesti sljedeći zaključci:

1. kompjutorskom aksiografijom zabilježene su kretnje mišićnih poremećaja, ali standardne putanje te modele za slučajeve u toj fazi nije bilo moguće dobiti;
2. dok kompjutorska aksiografija daje podatke o funkcionalnom stanju zgloba, magnetska rezonancija ima ključnu zadaću u određivanju stvarnog stanja pacijenta. Važno je pravilno povezati informacije, tako da se kombiniraju te dvije metode, jer su obje vrlo korisne za dobivanje objektivnih nalaza i postavljanje dijagnoze TMP-a.

stage by means of only computerized axiographical recordings. While it is possible to distinguish temporomandibular disorder cases as muscular stage and intraarticular disorder by means of axiographic recordings, in our study, no clear models of axiographic recordings to define the stages of intraarticular disorders (as regards neither the position of the disc, nor the degeneration of tissue) have been determined.

For many 'standard' TMD cases, simpler diagnostic tools will be adequate, but for particular cases additional information may be needed (28). Computerized axiography and MRI can successfully be used in conjuction with one another to increase the accuracy of positive and differentiated diagnosis (29). In compliance with the previous study, we used both computerized axiography and MRI in our study design.

The topics which need further studies to be evaluated and have not been fully investigated in this study, where computerized axiography recordings about healthy cases and TMD cases defined by means of computerized axiography have been evaluated, can be summarized as follows: diagnosis criteria for computerized axiography tracings about muscular stage cases can be developed by studying more cases than temporomandibular disorder ones; as for cases with disc displacements and other joint conditions, diagnostic index can be developed by associating MRI data with computerized axiography recordings.

Conclusion

Within the limitations of this study, the following conclusions can be drawn:

1. The traces were obtained from the cases with muscle disorders, but standard traces and models about the cases at this stage could not be developed with computerized axiography.
2. While computerized axiography render information about the functional condition of the joint, MRI plays a crucial role in determining the actual state of patients. The important thing is to relate the information in the right way by combining these two methods that both are quite useful in obtaining objective findings for diagnosis of TMD.

Abstract
Objective: In addition to the clinical evaluation, it was aimed to assess the traces obtained by computerized axiography of the condylar movements in temporomandibular disorders (TMD) in healthy individuals together with disc displacements and staged MRI images of these traces obtained in other joint positions. **Material and Methods:** 18 cases with muscle disorders (16 women and 2 men with mean ages; 32.06±15.99) and 11 cases (11 women, mean age 25.27 ±10.05) observed to have intraarticular disorders at different degrees as a result of MRI evaluation. The control group consisted of 10 cases (6 women and 4 men with mean ages; 22.20 ±2.39). Computerized axiography recordings of all cases were taken. MRI images taken from the cases with intraarticular disorders were evaluated. Joint sounds and mandibular range of motion were evaluated. Data were analyzed statistically. (Mann Whitney-U, Student t-test, One-way ANOVA and Chi-Square α=0.05). **Results:** The differences between TMD groups and control groups as regards the degrees of mouth opening movement were insignificant (p=0.27). The difference between the internal derangement and muscle disorder groups regarding TMJ sounds were insignificant (p=0.09). The length of the tracings of the asymptomatic control group as regards TMJs was generally symmetrical and in normal range. The tracings of the muscle disorder group were generally similar to those of the control group, however, the reproducibility of the movement was not as good as that in the control group. The tracings of patients with different stages as diagnosed by MRI were shorter than normal, and deviations on pathways in all cases, and crossings in some, were observed. **Conclusion:** In addition to careful clinical evaluation, function-based diagnosis techniques and imaging systems were utilised. Bony structures and especially soft tissues of the TMJ can be examined by means of MRI and the relations of the tissues with each other can be evaluated. In the method rendering information about the functional condition of the joint, objective data can be filed and the process of treatment can be evaluated.

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Address for correspondence
Dr. Gülcan Coşkun Akar
Ege University, School of Dentistry
Department of Prosthodontics,
35100 Izmir, Turkey
gulcan.coskun.akar@ege.edu.tr

Key words
Temporomandibular Joint Disorders; TMJ Diseases; Radiography

References

1. Schmitter M, Kress B, Rammelsberg P. Temporomandibular joint pathosis in patients with myofascial pain: a comparative analysis of magnetic resonance imaging and a clinical examination based on a specific set of criteria. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2004;97(3):318-24.
2. The glossary of prosthodontic terms. J Prosthet Dent. 1999;81(1):39-110.
3. Westesson PL, Larheim TA, Tanaka H. Posterior disc displacement in the temporomandibular joint. J Oral Maxillofac Surg. 1998;56(11):1266-73.
4. Liedberg J, Panmekiate S, Petersson A, Rohlin M. Evidence-based evaluation of three imaging methods for the temporomandibular disc. Dentomaxillofac Radiol. 1996;25(5):234-41.
5. Naeije M, Huddleston Slater JJ, Lobbezoo F. Variation in movement traces of the kinematic center of the temporomandibular joint. J Orofac Pain. 1999;13(2):121-7.
6. Piehslinger E, Celar A, Celar R, Jäger W, Slavicek R. Reproducibility of the condylar reference position. J Orofac Pain. 1993;7(1):68-75.
7. Slavicek R. Clinical and instrumental functional analysis for diagnosis and treatment planning. Part 5. Axiography. J Clin Orthod. 1988;22(10):656-67.
8. Piehslinger E, Celar AG, Celar RM, Slavicek R. Computerized axiography: principles and methods. Cranio. 1991;9(4):344-55.
9. Parlett K, Paesani D, Tallents RH, Hatala MA. Temporomandibular joint axiography and MRI findings: a comparative study. J Prosthet Dent. 1993;70(6):521-31.
10. Dworkin SF, LeResche L. Research diagnostic criteria for temporomandibular disorders: review, criteria, examinations and specifications, critique. J Craniomandib Disord. 1992;6(4):301-55.
11. Vogl TJ. MRI of the head and neck: functional anatomy, clinical findings, pathology, imaging. Berlin Heldberg: Springer-Verlag; 1992.
12. Gsellmann B, Schmid-Schwap M, Piehslinger E, Slavicek R. Lengths of condylar pathways measured with computerized axiography (CADIAX) and occlusal index in patients and volunteers. J Oral Rehabil. 1998;25(2):146-52.
13. Ozawa S, Tanne K. Diagnostic accuracy of sagittal condylar movement patterns for identifying internal derangement of the temporomandibular joint. J Orofac Pain. 1997;11(3):222-31.
14. Piehslinger E, Schimmerl S, Celar A, Crowley C, Imhof H. Comparison of magnetic resonance tomography with computerized axiography in diagnosis of temporomandibular joint disorders. Int J Oral Maxillofac Surg. 1995;24:13-9.
15. Shibasaki K, Fujita Y, Yamasawa H, Fukuyama E, Soma K. Development of a new device for recording condylar head movement. J Oral Rehabil. 2000;27(3):245-9.
16. Huddleston Slater JJ, Lobbezoo F, Chen YJ, Naeije M. A comparative study between clinical and instrumental methods for the recognition of internal derangements with a clicking sound on condylar movement. J Orofac Pain. 2004;18(2):138-47.
17. Rammelsberg P, Pospiech P, May HC, Gernet W. Evaluation of diagnostic criteria from computerized axiography to detect internal derangements of the TMJ. Cranio. 1996;14(4):286-95.
18. Rozencweig G. Comparative evaluation of two means of investigating craniomandibular dysfunction: axiography and magnetic resonance imaging. Rev Orthop Dento Faciale. 1991;25(2):205-13.

19. Yatabe M, Zwijnenburg A, Megens CC, Naeije M. Movements of the mandibular condyle kinematic center during jaw opening and closing. J Dent Res. 1997;76(2):714-9.
20. Morneburg T, Pröschel PA. Differences between traces of adjacent condylar points and their impact on clinical evaluation of condyle motion. Int J Prosthodont. 1998;11(4):317-24.
21. Farrar WB. Characteristics of the condylar path in internal derangements of the TMJ. J Prosthet Dent. 1978;39(3):319-23.
22. van Willigen J. The sagittal condylar movements of the clicking temporomandibular joint. J Oral Rehabil. 1979;6(2):167-75.
23. Mauderli AP, Lundeen HC, Loughner B. Condylar movement recordings for analyzing TMJ derangements. J Craniomandib Disord. 1988;2(3):119-27.
24. Kircos LT, Ortendahl DA, Mark AS, Arakawa M. Magnetic resonance imaging of the TMJ disc in asymptomatic volunteers. J Oral Maxillofac Surg. 1987;45(10):852-4.
25. Ribeiro RF, Tallents RH, Katzberg RW, Murphy WC, Moss ME, Magalhaes AC, et al. The prevalence of disc displacement in symptomatic and asymptomatic volunteers aged 6 to 25 years. J Orofac Pain. 1997;11(1):37-47.
26. Larheim TA, Westesson P, Sano T. Temporomandibular joint disk displacement: comparison in asymptomatic volunteers and patients. Radiology. 2001;218(2):428-32.
27. Romanelli GG, Harper R, Mock D, Pharoah MJ, Tenenbaum HC. Evaluation of temporomandibular joint internal derangement. J Orofac Pain. 1993;7(3):254-62.
28. Tymofiyeva O, Proff P, Richter EJ, Jakob P, Fanghänel J, Gedrange T, et al. Correlation of MRT imaging with real-time axiography of TMJ clicks. Ann Anat. 2007;189(4):356-61.
29. Schmid-Schwap M, Briedl JG, Robinson S, Piehslinger E. Correlation between disk morphology on MRI and time curves using electronic axiography. Cranio. 2005;23(1):22-9.