

# Comparative Study of Condylar Inclination Settings in Two Types of Semiadjustable Articulators

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## ABSTRACT

*The purpose of this study was to research the possible influence of difference in construction of mechanical joint in arcon and nonarcon articulators, upon the adjustment of condylar inclination by intraoral protrusive record. The determination of condylar inclination by protrusive record in two types of articulators was performed on 30 examinees, and the adjustment of condylar inclination in each articulator was done for left and right joint. In arcon articulator the measured values for condylar inclination were higher and the mean difference for right joint was 7.4°, and for the left joint 7.2°. The found differences are statistically significant for both, left and right joint, at the level of  $P < 0.001$ . There is possible influence of difference in construction of mechanical joint upon the adjustment of condylar inclination by intraoral protrusive record. The arcon articulator, due to constant relation between occlusal plane and mechanical fossa, reproduces the movements more accurately.*

**Key words:** *prosthetics, temporomandibular joint, dental articulators*

## Introduction

Articulators are mechanical devices which can accurately simulate the mandibular movements, and are used in diagnostic and therapeutic purposes<sup>1</sup>. In clinical practice, we most frequently use them in fabrication of removable and fixed dentures. Occlusal adjustments of occlusal surfaces, especially at fixed dentures, can be time consuming, difficult and sometimes frustrating<sup>2</sup>. In individually adjusted articulator, meaning the articulator with precisely determined condylar inclination and Bennett's angle, the mandibular movements can be accurately simulated. Accurate simulation of mandibular movements enables the fabrication of prosthetic restoration, i.e. occlusal surfaces with individually shaped cusps, the height and inclination of which are compatible with the condylar guidance<sup>3</sup>. Prosthetic restoration fabricated in such a way will require minimal intraoral adjustment, and will therefore have completely preserved occlusal surfaces<sup>4</sup>. Additionally, the accurate performance of movements in

the articulator provides the opportunity to detect and eliminate the premature and undesired contacts (interferences).

Arcon and nonarcon type of articulator differ in structure of mechanical joint. In arcon articulator mechanical condyls are in the lower part of the articulator, which corresponds to the mandible, and artificial fossa articularis are in the upper part of articulator, which corresponds to the maxilla. In nonarcon type of articulator, the position of joint parts is reversed<sup>1</sup>.

In everyday practice average values for condylar inclination are often used despite the facts that condylar inclination varies interindividually, that there is difference in inclination between left and right joint and between female and male<sup>5,6</sup>. The proper orientation of cast in articulator is possible if the mechanical axis and the intercondylar distance of the articulator is identical to

the hinge axis and the intercondylar distance of temporomandibular joint<sup>5,7,8</sup>. When the casts are mounted in a semi-adjustable articulator by use of a facebow, and condylar guidance is individually adjusted by intraoral records or extraoral method, a close approximation of mandibular movements can be obtained<sup>4,9</sup>.

The most frequently used method is the articulator individualization by eccentric interocclusal records<sup>10,11</sup>. The procedure is simple and quick, and applicable in daily clinical practice. The accuracy of the articulator adjustment depends upon the choice of material used for records, the method of procedure and the skill of the therapist<sup>2,11</sup>.

Since both types of semi-adjustable articulators (arcon and nonarcon) are widely used in daily practice, the purpose of this study was to research the possible influence of difference in construction of mechanical joint in each of them, upon the adjustment of condylar inclination by intraoral protrusive record.

## Materials and Methods

The determination of condylar inclination by protrusive record in two different types of articulator (arcon and nonarcon) was performed on 30 examinees, 14 female and 16 male. They all had full dental arches in both jaws and no signs or symptoms of temporomandibular joints disorder. The remaining teeth were intact, and occlusion was stable with class I intermaxillar relations (Table 1).

**TABLE 1**  
EXAMINEES, DENTAL STATUS (MISSING TEETH)  
AND AVERAGE AGE

	N	AVERAGE OF MISSING TEETH	AVERAGE AGE
FEMALE	14	4	26.7
MALE	16	5	32.8
TOTAL	30	5	30.6

N – number of examinees

Both articulators, arcon and nonarcon, used in the study were semi-adjustable and of the same production (Artex, Girbach Dental GmbH Pforzheim, Germany). The instruments were adjusted by manufacturer, in working order and undamaged.

The impressions of upper and lower dental arch, two for each jaw, were taken from the examinees. They were made by commercial trays and irreversible hydrocolloid-alginate (Aroma Fine DF III, GC Corporation Tokyo, Japan). The impressions were then cast, by using extra hard plaster type 4 (Fujirock® EP Type IV, GC Corporation Tokyo, Japan), and two study models for each jaw were obtained.

The registration of maxillary position was made by quick mounting facebow (Rotofi-Girbach Dental GmbH

Pforzheim, Germany), and infraorbital point (the highest osseous point of orbit), i.e. Frankfurt orientation plane, was used as front point of reference. The position of centric relation was registered by making the front deprogramator (jig) from self-curing acrylic resin (Pattern resin GC Corporation Tokyo, Japan). The centric record itself, was made of hard wax (Kerr Set Up Wax No 5, Kerr, USA) and paste (Freegenol Temporary Cement GC Corporation Tokyo, Japan) using the bimanual manipulation technique. The centric relation was registered in increased intermaxillary relation in average of 3mm, and the same centric record was used in both articulators.

Before protrusive registration, the anterior protrusive guideline (jig) from the same self-curing acrylic resin, was made. The jig was obtained by guiding the patient's mandible symmetrically into protrusive position with incisors in edge to edge position. The protrusive record was made in that position, using the same material as for centric record, i.e. combination of hard wax and paste. The amount of protrusive movement was not measured because it had no influence on finding the difference between two types of articulators.

Further on, the casts were mounted into articulators. The upper jaw casts were mounted into upper parts of both types of examined articulators, by using the same facebow. Casts of lower jaw were joined to the upper ones by wax centric records, and mounted into lower parts of both articulators. In such a way, the casts were mounted in both articulators by the same facebow and the same centric record. The adjustment and recording of condylar inclination for left and right joint was done in both articulators. For this purpose the protrusive record was used, condylar inclination in both articulators was set to starting position 0, and all screws fixing the condylar balls were loosened. The artificial joints in articulator were adjusted to the protrusive record, and angles of condylar inclination for left and right joint were read in both articulators.

Numeric results for the condylar inclination have been processed by computer, using a statistical software package: Statistica for Windows, Version 6.0 Tulsa OK, USA: StatSoft Inc.2000. Statistical analysis was performed using descriptive statistics. The statistically significant difference between values for condylar inclination, measured for both joints in arcon and nonarcon articulator, was performed using Student's t-test for independent samples.

## Results

The average age of examinees was 30.6, but the majorities were the age group 18–27.

The obtained values for condylar inclination for left and right angle in arcon and nonarcon articulator are shown in Table 2. The values were obtained by setting both articulators with the same protrusive record which guarantee the identical conditions in both articulators during settings. The amount of protrusive movement was also the same (same protrusive record) in both

**TABLE 2**  
DESCRIPTIVE STATISTIC FOR MEASURED VALUES OF  
CONDYLAR INCLINATION IN ARCON AND NONARCON  
ARTICULATOR FOR RIGHT AND LEFT JOINT

Variables	N	R	MIN	MAX	M	SD
RA	30	25	25	50	36.67	7.76
LA	30	30	25	55	36.90	8.39
RN	30	28	17	45	29.27	8.22
LN	30	33	17	50	29.73	8.47

RA – right arcon, LA – left arcon, RN – right nonarcon, LN – left nonarcon, N – number, R – range, M – mean, SD – standard deviation

articulators for each examinee, but the values were not measured because these values were not essential in determination the difference between instruments (articulators).

The mean value of right joint of condylar inclination in arcon articulator was 36.7°, while for left joint the mean value of inclination was 36.9°. In nonarcon articulator the measured values for condylar inclination were lower: for right joint, the measured mean value was 29.3°, and for left joint 29.7°.

The distribution of differences in values of condylar inclination between arcon and nonarcon articulator (Figure 1) evidently shows, that in arcon type of articulator, the obtained value of inclination for the right joint was higher for 7.4° in average, while the most frequent difference was between 7°–9° (21 of 30 measured differences). The similar values were obtained for the left joint, where the average value of inclination in arcon type of articulator was higher for 7.2°, and the most frequently obtained difference was also between 7°–9°, and 21 of 30 differences were in that range (Figure 2).

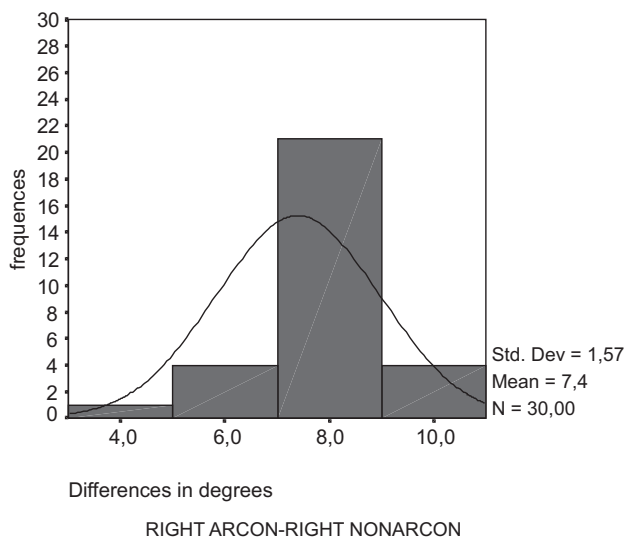


Fig. 1. Differences for condylar inclination in right joint shows most frequent values of differences between 7–9 degrees.

The found differences for condylar inclination between the examined articulators are statistically significant for both left and right joint at the level of  $P < 0.001$  (Table 3).

In order to eliminate any possible mistakes during the mounting of casts into articulator and adjustment of inclination in the articulator joint, the differences in values of inclination between right and left joint in each type of articulator were measured. The obtained values of differences were compared and was not statistically significant ( $P = 0.660$ ).

## Discussion

Two common methods for setting the condylar path inclination in articulators are intraoral method using the protrusive intraoral record, and extraoral tracing of protrusive movement with pantograph or axiograph. Electronic axiography is the most accurate method for recording of mandibular movement<sup>12–15</sup>, but its use is limited because it is time consuming, expensive, and high skills and education of the therapist are required. Clinical use of axiography, for setting a fully adjustable articulator is indicated in diagnostic procedure in patients with TMJ disfuncion, or extensive prosthetic oral rehabilitation in

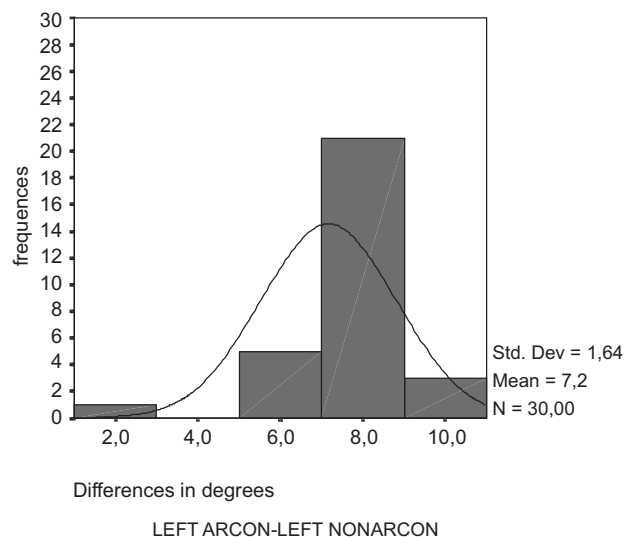


Fig. 2. Differences for condylar inclination in left joint shows most frequent values of differences between 7–9 degrees.

**TABLE 3**  
DIFFERENCES OF MEASURED VALUES FOR CONDYLAR  
INCLINATION IN ARCON AND NONARCON ARTICULATOR  
TESTED BY STUDENT T-TEST

	M	SD	SEM	t	df	SIG.
RA-RN	7.4	1.57	0.29	25.867	29	0.000
LA-LN	7.2	1.64	0.30	23.909	29	0.000

RA – right arcon, RN – right nonarcon, LA – left arcon, LN – left Nonarcon, mean, SD – standard deviation, SEM – standard error mean, t – t value, df – degrees of freedom, SIG – Significance

patients with signs and symptoms of TMJ disorders<sup>16</sup>. Optoelectronic axiography, with the equal accuracy due electronic axiography, has advantage of using simple equipment, the method is time-saving and the comfort experienced by patients is better<sup>17</sup>.

Mechanical axiography and interocclusal records showed greater divergence of results, lower repeatability of results through time, and, in average, lower measurement values<sup>17–19</sup>. Comparing the condylar inclination articulator setting obtained from protrusive wax record and extraoral tracing with pantograph, Santos et al.<sup>20</sup> conclude, that by using the intraoral wax protrusive method, decreased values for angle are obtained. Similar results are obtained in other studies with conclusion that measurements of extraoral tracing of condylar inclination gave higher values with less variation, in comparison with wax protrusive method<sup>13,21</sup>. Using the wax protrusive method Ecker et al.<sup>22</sup> found that the wax method produced lower readings with wider range of angles.

In our study, which was clinical orientated, intraoral method was utilized because it is simply, easy and quick method and it is usually provided in daily clinical practice.

Selection of materials for intraoral records proved to be very important factor in the transfer procedure. Wax, as most common material in daily use, proved to be the least precise, due to high thermal expansion coefficient and big deformations under compression<sup>23–27</sup>.

Besides wax, quite a number of other materials are used for records: plaster, ZOE paste, acrylic resins, elastomers. From elastomers, silicones and polyethers showed good properties, while additional silicones due to their dimensional stability, even under compression, proved to be the most precise<sup>11,28</sup>.

Other problems with the intraoral method, regardless of the material used, are that the condylar inclination changes with the degree of protrusion, and that the intraoral record represents only one point along the condylar path. If the protrusive displacement of the mandible is six or more millimeters it may result in decreased condylar inclination<sup>13</sup>. Clinical implications of lower condylar inclination may result in restoration with decreased cusp height and could also avoid development of interferences in restorations but could also indicate interferences in the articulator that are not presented in the patients<sup>20</sup>. Generally, the condylar inclination adjustment affected the cusp heights in the protrusive and nonworking excursion without affecting the working excursion<sup>29</sup>. In the present study the amount of protrusion was acceptable for determining condylar inclination. The amount of protrusive movement was not measured because the aim of this study was not to give an accurate analysis of condylar inclination and protrusive movement, but to compare two different instruments (articulators) using the same protrusive record.

In addition, the plane of reference during measurement is a relevant parameter to consider, because condylar inclination values cannot be compared when obtained with different planes of reference<sup>30–32</sup>.

Comparing the results of condylar inclination and Bennet's angle on three different semi-adjustable articulators, obtained by protrusive and lateral records, Gross et al.<sup>19</sup>, got statistically significant differences for all three devices. The highest values of measured inclinations were on arcon (Denar Mark II) articulator, and the lowest on nonarcon (Hanau 158) articulator. The difference was found in all three measurements with eccentric records made of different materials, with mean difference value of 13°.

In this study, lower values of condylar inclination were measured in nonarcon articulator, for 7.3° in average, and the difference in relation to condylar inclination in arcon articulator shows statistical significance ( $P < 0.001$ ). This difference is caused by different construction of mechanical joint in arcon and nonarcon articulator. It is known that in arcon articulator, the change in vertical dimension does not alter the angle closed by mechanical fossa and occlusal plane of upper teeth. In nonarcon articulator, due to reversed construction of mechanical joint, the change in vertical dimension in articulator changes this angle. Since the setting of condylar inclination happens in increased vertical position due to thickness of interocclusal record in relation to working height of articulator, this is the probable reason for the found difference, and confirms the assumption of this study.

Therefore, the arcon articulator, due to constant relation between occlusal plane and mechanical fossa, reproduces the movements more accurately. In daily clinical practice, errors in fabrication of prosthetic restorations, caused by construction of mechanical joint, are practically negligible. In education, arcon articulator is more suitable for the beginners, since the movements are identical to those of natural joint, and therefore easy to comprehend.

## Conclusions

The results obtained in this study lead to the following conclusions:

1. The values of condylar inclination, obtained by protrusive records, in nonarcon articulator were lower in relation to arcon articulator for 7.3° in average
2. The obtained differences in condylar inclination between two types of articulator were statistically significant ( $P < 0.001$ ) for values measured in both joints (left and right)
3. The reason for found differences is the different construction of joint parts in these two types of articulators

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## USPOREDBA NAGIBA KONDILNE STAZE U DVIJE RAZLIČITE VRSTE POLUPRILAGODLJIVIH ARTIKULATORA

### SAŽETAK

Svrha ovoga rada je istražiti utječe li različita konstrukcija mehaničkog zgloba kod arkon i nonarkon artikulatora, na ugađanje nagiba kondilne staze pomoću intraoralnog protruzijskog registrata. Ugađanje nagiba kondilne staze pomoću protruzijskog registrata u dva tipa artikulatora izvršeno je na 30 ispitanika, a mjerenje nagiba kondilne staze u svakom artikulatoru je bilo za desni i lijevi zglob. Izmjerene vrijednosti za nagib kondilne staze u arcon artikulatoru su bile više, a srednja vrijednost razlike za desni zglob je bila  $7,4^\circ$ , a za lijevi  $7,1^\circ$ . Nađene razlike su bile statistički značajne za desni i lijevi zglob na razini  $P < 0,001$ . Može se zaključiti da postoji mogućnost da različita konstrukcija mehaničkog zgloba utječe na ugađanje kondilne staze metodom ekscentričnog protruzijskog registrata. Arcon artikulator, zbog konstantnog odnosa između okluzijske ravnine i mehaničke zglobne jamice, reproducira pokrete preciznije u odnosu na nonarcon artikulator.