

Reproducibility of lateral excursive tooth contact in a semi-adjustable articulator depending on the type of lateral guidance

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SUMMARY The purposes of this study were (i) to compare the reproducibility of lateral tooth contacts of casts mounted in a semi-adjustable articulator when condylar guidance was set by different methods and (ii) to assess the margin of error of the variations of condylar guidance without changing lateral tooth contacts, depending on the type of lateral guidance. In subjects with different types of lateral guidance, intraoral lateral tooth contacts identified with occlusal registration strips were compared with those identified by use of a semi-adjustable articulator, setting the condylar guidance in four different ways: using protrusive wax wafers, by axiography and by adding and subtracting 5° from the value of condylar guidance obtained by protrusive wax wafers. Tolerance to variations of condylar guidance without changing lateral tooth

contacts was determined by increasing and decreasing the value of condylar guidance until lateral tooth contacts changed. Different ways of setting condylar guidance on a semi-adjustable articulator give rise to different values of condylar guidance in the same subject. The occlusal repercussions of these variations of condylar guidance values depend on the type of lateral guidance. Canine protection had the greatest tolerance to variations in the setting of condylar guidance without changing lateral occlusal contacts.

KEYWORDS: condylar guidance angle, semi-adjustable articulator, lateral guidance, axiography, protrusive record technique, excursive tooth contact

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Introduction

Articulators are used to simulate occlusal contacts in stone casts for diagnostic and restorative procedures. Semi-adjustable articulators are taught in undergraduate dental educational programmes and are recommended to enhance clinical practice (1, 2). Nevertheless many dentists do not use articulators because they consider that they can accomplish satisfactory results without it (3). The articulator technique requires recording of individual mandibular movements to transfer and mount the casts on the articulator, in addition to programming of the articulator. The interocclusal record technique and axiography are used to set condylar guidance on semi-adjustable articula-

tors, and several papers have studied different methods to assess their reliability (4-6). Nevertheless, very few studies have used the values of condylar guidance obtained to assess the reproduction of excursive tooth contacts on an articulator. Tamaki et al. assessed the reproduction of excursive tooth contacts with the aid of computerized axiography, but this technique is not within the reach of the general practitioner (7).

The purposes of this study were (i) to compare the reproducibility of lateral tooth contacts of casts mounted in a semi-adjustable articulator when condylar guidance is set by different methods, depending on the type of lateral guidance and (ii) to assess the margin of error of the variations of condylar guidance without changing lateral tooth contacts, depending on the type

of lateral guidance. The rationale of this study was to outline a simple technique of mounting casts in a semi-adjustable articulator for use in general practice.

Materials and methods

Subjects

Seventeen dentate subjects (10 women and seven men) were recruited from students of the Faculty of Dentistry of the University of Barcelona. Their ages ranged from 18 to 25 years (average 22.3 ± 2.7 years). The criteria for selection was as follows: (1) to exhibit natural dentition with no missing teeth (except third molars), (2) to be healthy, without oral pathology or temporomandibular disorders, (3) to obtain at least, 10 lateral guidance for each type (canine protection, anterior guidance and group function). Informed consent was obtained from each subject.

Recording of intraoral guidances

Recordings of the intraoral lateral tooth contacts were performed with occlusal registration strips (Bausch® Articulating Paper BK09 40 µm)* with the subjects seated in an upright position. The examiner requested the subjects to close into intercuspal position and the recording was drawn on the protocol sheet (Fig. 1). Afterwards the examiner requested the subjects to perform first right and secondly left lateral movements of the mandible while they kept constant contact between maxillary and mandibular teeth and each recording was drawn on the protocol sheet. One examiner made all recordings to avoid interexaminer variation and each recording was performed twice with an interval of few minutes. The intraclass correlation coefficient was 0.98. Recordings of the first 2-mm gliding for both sides were drawn on a protocol sheet and were classified as: canine protection, anterior guidance, group function and group function with balancing contacts. Canine protection was defined as the contact of only working side maxillary and mandibular canines in the total range of motion. Anterior guidance was defined as the contacts of one or more incisors without posterior contact. Group function was defined as the contact of at least one or more posterior working side teeth.

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Group function with balancing contacts was defined as the contacts of both working and non-working side teeth.

Fabrication of casts and mounting

Alginate impressions (Algisul® ADA 18 - ISO 1563)[†] of the maxillary and mandibular arches were taken and poured with stone (Kimberlit®, Extra-hard High-Density die stone type 4 ISO 6873)[‡]. The maxillary cast was mounted with plaster (Snow-White Plaster® num. 2 ISO type I)[§] in a semi-adjustable articulator (Dentatus ARH®)[¶] using the Dentatus arbitrary hinge face-bow. The mandibular cast was mounted in intercuspal position without any registration, fitting the casts together.

Articulator adjustment

Articulator settings were made separately according to two methods. The first setting of the condylar guidance angle (CGA) was made by the protrusive record technique. After training the subject was instructed to protrude the mandible a distance of 5 mm and a record was made with wax (Moyco® Beauty Pink x-hard 116-56630)** previously heated at 55 °C in a water bath. The Bennett angle was calculated with the Hanau formula. The second setting of CGA was made with axiography (Axio-Quick®)^{††}, according to the manufacturer's instructions (Fig. 2). This technique uses an arbitrary hinge axis (Fig. 3). The mandibular clutch carrying the lower face-bow was cemented with plaster (Snow-White Plaster® num. 2 ISO type I)[§] to the anterior and premolar teeth. Mandibular protrusion was recorded with manual guidance by the examiner. The CGA was obtained at the first 3 mm of protrusion (Fig. 4). Because the intrasubject variability in recording the CGA with the protrusive record technique is about 5° (8, 9), two more settings were made by adding and subtracting, respectively, 5° from the value of condylar guidance obtained by the protrusive record technique. After each setting, right and left lateral tooth

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Intraoral tooth contacts

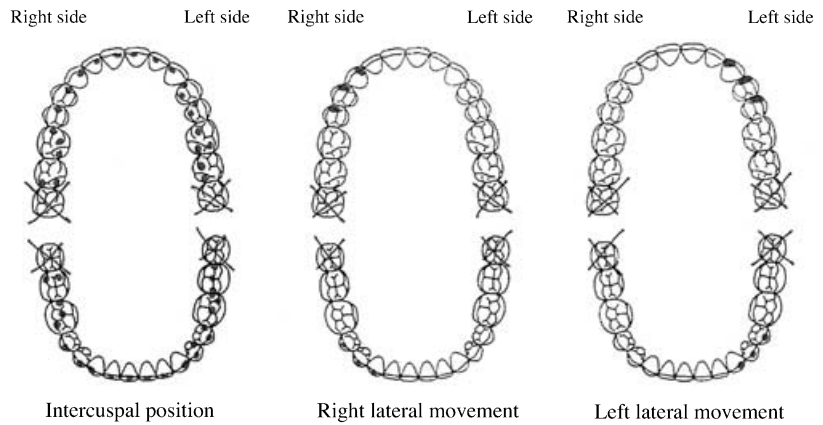


Fig. 1. Part of the protocol sheet from a subject with group function. These drawings were repeated five times for each subject and were used to mark the tooth contacts observed intraorally, and in casts mounted in a semi-adjustable articulator set in four different ways: using protrusive wax wafers, by axiography, and by adding and subtracting 5° from the value of condylar guidance angle obtained by protrusive wax wafers.



Fig. 2. Axiograph (Axio-Quick®) assembled on a subject.

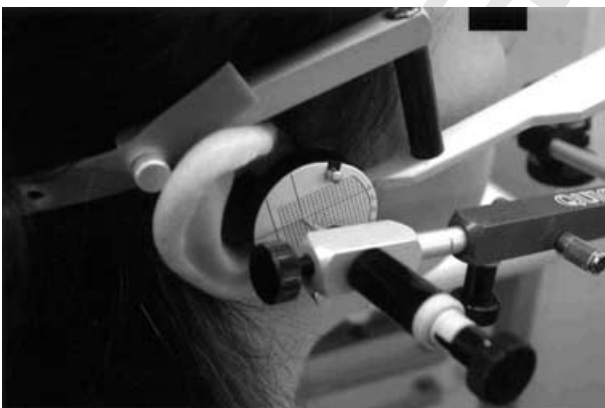


Fig. 3. Axiograph (Axio-Quick®): arbitrary hinge axis.

contacts of the casts were recorded with articulating paper (Bausch® Articulating Paper BK09 40 µm)* and transferred to the protocol sheet.

Degree of coincidence between intraoral lateral tooth contacts and articulator lateral tooth contacts

The degree of coincidence between intraoral lateral tooth contacts and articulator lateral tooth contacts set by axiography and by the protrusive record technique was determined for left and right laterotrusions in the four lateral guidance groups, using the drawings on the protocol sheet, observing the maintenance of the functional group and, if it was so, observing that the same teeth maintained contact.

Margin of error of lateral guidance groups to variations of CGA

The value of CGA determined by axiography was taken as a reference to find the margin of error to variations of CGA for each lateral guidance group. This CGA value was either progressively increased or decreased until the type of lateral guidance changed or a different first contact appeared.

Statistical analysis

Data from double repeated CGA measurements were averaged. Student's *t*-test and paired Student's *t*-test were used to examine differences between left versus right CGA and differences in CGA obtained by axiography and protrusive record technique, respectively. Wilcoxon and Mann-Whitney tests were used to examine differences between agreement of the techniques and margin of error of lateral guidance groups, respectively. Levels of *P* < 0.05 were deemed statistically significant.



Fig. 4. Sagittal axiographic tracing of protrusive movement (Axio-Quick®).

Results

Condylar guidance angle

The CGAs on each side obtained by each method are presented in Table 1. There was no significant difference in the angles between right and left side in both techniques ($P = 0.91$ with axiography and $P = 0.51$ with protrusive record technique). The CGAs measured by axiography were significantly higher than those obtained by the protrusive record technique (mean of difference 10.2, CI 95% 5.5–14.9) and a significant correlation was found ($r = 0.53$, $P = 0.001$).

Agreement between intraoral and articulator contacts

Table 2 shows the agreement between intraoral and articulator contacts when the articulator was set by means of different procedures. Generally, a higher percentage of agreement was observed in the canine protection group followed by anterior guidance. A low

Table 1. Mean (range) \pm s.d. of condylar guidance angles ($^{\circ}$) obtained by axiography and protrusive record technique

	<i>n</i>	Right	Left
Axiography	17	42.8 (20–70) \pm 14.5	42.1 (0–59) \pm 17.2
	34	42.4 (0–70) \pm 15.7	
Protrusive record	17	31.1 (15–55) \pm 11.6	33.4 (10–45) \pm 8.6
	34	32.2 (10–55) \pm 10.1*	

* $P < 0.001$ compared with Axiography (Paired *t*-test).
n, number of side subjects.

percentage of agreement in group function and an absence of agreement in group function with balancing contacts were observed. Considering the technique employed to set the condylar guidance, the higher percentage of agreement was observed with axiography followed by the protrusive record technique plus 5°, followed by the protrusive record technique and, finally, the protrusive record technique minus 5°. Setting the articulator using axiography reproduced the lateral contacts significantly better than with the protrusive record technique in anterior guidance and group function.

Margin of error of the different types of lateral guidance to variations of CGA

In both cases of canine protection and anterior guidance, there was no change in tooth contacts when the CGA was increased. In all six cases with group function analysed, the type of lateral guidance was maintained when increasing the CGA. However, four cases (66%) showed a change of tooth in contact when an average of 9° was increased, observing that the most posterior contacts disappeared. Group function with balancing contacts was not analysed because there was no agreement between intraoral contacts and articulator contacts.

Table 3 shows the margin of error to reductions of CGA for those cases in which the articulator lateral contacts agreed with intraoral lateral contacts. The type of lateral guidance that showed the greatest margin of error was canine protection. In all groups discrepancies were because of the appearance of posterior contacts on the non-working side.

Discussion

Different ways of setting condylar guidance on a semi-adjustable articulator give rise to different values of CGA in the same subject (5, 10) and it is foreseeable that lateral tooth contacts in casts mounted on a semi-adjustable articulator set by those methods will also be different. In this study, as found by other authors, the mean of the CGA obtained by axiography was 10.2° greater than that obtained by the protrusive record technique.

In all cases, the greatest coincidence in the type of lateral guidance as well as lateral tooth contacts between intraoral situations and casts mounted in

Table 2. Percentage of agreement between intraoral contacts and contacts observed with the articulator set with different procedures

Lateral guidance	<i>n</i>	Axiography	Protrusive record + 5°	Protrusive record	Protrusive record – 5°
Canine protection	11	100 ^{*,†}	100 ^{*,†,‡}	82 ^{*,†}	64 ^{*,†}
Anterior guidance	10	80 ^{†,§}	50 [†]	40 [*]	10
Group function	10	60 ^{†,§}	40 ^{†,§}	0	0
Group function with balancing contacts	3	0	0	0	0

*Significant differences ($P < 0.05$) compared with group function and group function with balancing contacts (*U*-Mann–Whitney).

†Significant differences ($P < 0.05$) compared with anterior guidance (*U*-Mann–Whitney).

‡Significant differences ($P < 0.05$) compared with protrusive record minus 5° (Wilcoxon test).

§Significant differences ($P < 0.05$) compared with protrusive record technique (Wilcoxon test).

Table 3. Margin of error to reductions of condylar guidance angle (CGA) (°) with no change of occlusal contacts

Lateral guidance	<i>n</i>	Original non-working CGA	Last non-working CGA	Margin of error
Canine protection	11	47 (13); 29–70	24 (12); 5–42	23 (13); 6–48
Anterior guidance	8	35 (12); 20–52	25 (11); 13–42	9 (8); 2–22*
Group function	6	50 (10); 35–58	43 (8); 32–54	7 (4); 2–13**
Group function with balancing contacts	0			

Mean (s.d.); range. * $P < 0.05$, ** $P < 0.01$ compared with canine protection group (*U*-Mann–Whitney). Last non-working CGA means the CGA at which there is the change on the type of lateral guidance or on teeth in contact.

semi-adjustable articulator was found when the CGA was set by axiography. It is followed in order from more to less by the protrusive record technique plus 5°, the protrusive record technique, and finally the protrusive record technique minus 5°. The results suggest that, in general, axiography is a more reliable method for programming a semi-adjustable articulator than is the protrusive record technique, although possible errors may occur in producing the mounted casts, and the limitations of occlusal registration strips. Some studies demonstrated that the setting of semi-adjustable articulators using the interocclusal record technique produced low levels of reproducibility (5, 8, 11, 12). Nevertheless, results of this study show that the type of lateral guidance greatly influences the reproducibility of lateral tooth contacts: in all methods of setting the CGA, canine protection showed the greatest reproducibility, followed by anterior guidance and, finally, by group function. None of the three cases of group function with balancing contacts was reproduced in the semi-adjustable articulator.

The contact discrepancies in canine protection and anterior guidance were because of the appearance of non-working side contacts. The type of contact discrepancies observed in group function depended on the articulator setting: when the articulator was set using axiography, the same type of lateral guidance was

maintained but the teeth actually in contact were different. However, when the articulator was set with the protrusive record technique, non-working side contacts appeared. In group function with balancing contacts there were no coincidences in tooth contacts, but the guidance pattern was maintained.

It is known from a mechanical point of view that the greater the value of CGA, the less likely it becomes to have lateral contacts between posterior teeth. It is noteworthy that axiography is the technique by which the higher levels of CGA are obtained and if values of CGA are artificially raised with casts mounted in the articulator, then the type of lateral guidance and lateral dental contacts does not change when the subject has a canine protection or an anterior guidance. If the subject has group function the type of lateral guidance is also maintained but there is a change in tooth contacts in 66% of cases, observing that the most posterior contacts disappeared. However, there are many more changes when the value of CGA is artificially reduced with casts mounted in the articulator depending on the type of lateral guidance: canine protection allows decreases of 23° on average and is still a canine protection, anterior guidance allows decreases of 9° and group function of 7°.

These facts mean that the greatest accuracy of axiography is probably not due to a greater agreement

with the real CGA of the subject but to the highest CGA values it confers. Therefore, if what is intended is an occlusal analysis with a semi-adjustable articulator of an individual with a canine protection or an anterior guidance, it is not necessary to register the CGA value as the articulator can be set directly at 70°. In cases of group function it is better to set the articulator with axiography or to add 10° to the value obtained by the protrusive record technique, being aware that in most cases there will be a difference between the intraoral tooth contacts and the contacts of the casts. In this study group function with balancing contacts could not be reproduced with a semi-adjustable articulator, but because the sample was small it is not wise to draw conclusions. This is also argued by other authors (13), who recommend the use of a fully adjustable articulator in cases of group function.

If what is intended is a prosthodontic restoration in the premolar or molar region of an individual with a canine protection or an anterior guidance, it is not necessary to register the CGA value either, but the articulator can be set directly at 20° in order to assure a low cuspid height. In cases of group function, a fully adjustable articulator has to be used or, if a semi-adjustable articulator is chosen, it should be set by axiography or by adding 10° to the value obtained by the protrusive record technique. Moreover, one must be aware that in most cases an intraoral adjustment will be necessary because of the differences between the intraoral tooth contacts and the contacts of the casts. In cases of group function with balancing contacts, a semi-adjustable articulator may not be able to reproduce the lateral tooth contacts.

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References

1. Cabot LB. Using articulators to enhance clinical practice. *Br Dent J.* 1998;184:272–276.
2. Gross MD, Gazit E. Articulators used in North American dental schools. *J Dent Educ.* 1985;49:710–711.
3. Clark DM, Oyen OJ, Feil P. The use of specific dental school-taught restorative techniques by practicing clinicians. *J Dent Educ.* 2001;65:760–765.
4. Pelletier LB, Campbell SD. Comparison of condylar control settings using three methods: a bench study. *J Prosthet Dent.* 1991;66:193–200.
5. Ecker GA, Goodacre CJ, Dykema RW. A comparison of condylar control settings obtained from wax interocclusal records and simplified mandibular motion analyzers. *J Prosthet Dent.* 1984;51:404–406.
6. Gross M, Nemcovsky C, Tabibian Y, Gazit E. The effect of three different recording materials on the reproducibility of condylar guidance registrations in three semi-adjustable articulators. *J Oral Rehabil.* 1998;25:204–208.
7. Tamaki K, Celar AG, Beyrer S, Aoki H. Reproduction of excursive tooth contact in an articulator with computerized axiography data. *J Prosthet Dent.* 1997;78:373–378.
8. Posselt U, Franzen G. Registration of the condyle path inclination by intraoral wax records: variations in three instruments. *J Prosthet Dent.* 1960;10:441–454.
9. Price RB, Bannerman RA. A comparison of articulator settings obtained by using an electronic pantograph and lateral interocclusal recordings. *J Prosthet Dent.* 1988;60:159–164.
10. Donegan SJ, Christensen LV. Sagittal condylar guidance as determined by protrusion records and wear facets of teeth. *Int J Prosthodont.* 1991;4:469–472.
11. Craddock FW. The accuracy and practical value of records of condyle path inclination. *J Am Dent Assoc.* 1949;38:697–710.
12. Gross M, Nemcovsky C, Friedlander LD. Comparative study of condylar settings of three semiadjustable articulators. *Int J Prosthodont.* 1990;3:135–141.
13. Hobo S, Shillingburg HT Jr, Whitsett LD. Articulator selection for restorative dentistry. *J Prosthet Dent.* 1976;36:35–43.

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