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SCIENTIFIC SECTION

Does articulating study casts make a difference to treatment planning?

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Abstract

Objective: To assess whether articulating casts in centric relation (CR) compared with intercuspal position (ICP) makes a difference to treatment planning.

Design: Reliability analysis.

Subjects: Ten orthodontists.

Methods: Twenty case vignettes were examined on three occasions: twice with the casts in ICP and once in CR. A series of dichotomous decisions were made relating to the treatment need and treatment mechanics.

Main outcome measures: The changes in treatment decisions were examined. Intra-examiner agreement between the two hand-held cast assessments (H1 *v.* H2) and between the first set of hand-held casts compared with the articulated casts (H1 *v.* A1) were evaluated using the kappa statistic. The differences between the kappa statistics for H1 *v.* H2 and H1 *v.* A1 were then tested with the Wilcoxon matched pairs signed rank sum test.

Results: The only statistically significant change in the kappa score between H1 *v.* H2 and H1 *v.* A1 was for the extraction decision ($P = 0.007$). No other statistically significant differences were found for the other treatment decisions, although trends were identified for orthognathic surgery and anchorage support decisions.

Conclusion: Routine articulation of study models for all orthodontic patients is not supported by the results of this study. Articulation of the study models did not affect the treatment planning decisions in a meaningful manner. Further work with selected samples is required to determine if articulation is helpful for specific malocclusions.

Index words: Centric relation, orthodontics, treatment planning.

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Introduction

The use of articulated study models has been advocated by a number of authors to aid diagnosis and treatment planning of orthodontic cases.[1–5] Supporters of articulation suggest that only by articulating the casts in centric relation (CR) can we examine the true contact of the teeth free from occlusal interferences.[1] Centric relation is when the condyles are in their anterior-superior position where they articulate with the thinnest avascular portion of the disc and hinge movement only occurs.[6] By contrast, orthodontically trimmed, hand-held casts, which are more commonly used for orthodontic treatment planning in the United Kingdom, record the teeth in the position of maximum intercuspation or intercuspal position (ICP).

Previous research has shown that study models are the most important diagnostic record in orthodontic treatment planning. For example, when Han[7] introduced diagnostic records sequentially, she found that 55 per cent of treatment plans devised from study casts alone were unchanged by the addition of further diagnostic records (photographs and radiographs).

Several studies[8,9] have found that inter-examiner agreement on treatment planning decisions is generally low, whilst intra-examiner agreement is slightly better. The agreement varied according to the decision taken and improved slightly for the important, irreversible decisions.[9]

The aim of this study was to assess whether the articulation of casts in CR would affect the treatment planning decisions of several practicing orthodontists.

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Materials and method

The methodology was based on that of a previous study conducted by Lee *et al.*[9] Ten specialist orthodontists, nine working in the British NHS hospital-based orthodontic services and one in specialist practice volunteered for this study. On three occasions, each a minimum of 2 weeks apart, the clinicians examined 20 case vignettes. The vignettes consisted of study casts, facial photographs (showing frontal, frontal smile, right lateral, and right oblique views), an OPG radiograph, a lateral cephalometric radiograph, and a tracing of the lateral cephalometric radiograph. In addition, an upper standard occlusal or periapical radiographs were included where these were deemed to be essential for treatment planning, e.g. for localization of an unerupted canine.

On two occasions, the case vignettes contained hand-held casts and, on one occasion, casts were articulated on a semi-adjustable (Dénar®) articulator. The orthodontists received the hand-held or articulated vignettes sets in random order on the three occasions, but would examine the cases in the same sequence each time, i.e. starting with case one and progressing to case 20.

The cases comprised of 20 consecutive patients commencing treatment with one of the authors (PE). They represented a wide range of malocclusions including Class I, II, and III skeletal patterns, hypodontia cases and cases where the maxillary canines were impacted (Table 1). All ICP and CR records were taken by the same operator (PE), and all casts were poured, trimmed, and mounted by the same orthodontic technician.

Centric relation records were taken using a technique similar to 'Roth's Power Centric relation Registration' as described by Wood *et al.*[10] The exception was that instead of Delar Bite Registration Wax (Delar Corp.), Moyco® Beauty Wax (Thompson Dental Manufacturing Company Inc., Missoula, USA) was used. Facebow recordings were taken according to the manufacturers instructions.

The clinicians were informed that 'all patients are motivated towards treatment and will accept an ideal treatment plan'. They were then asked to record their treatment plan as a dichotomous yes or no decision, on a data collection sheet containing the following broad treatment categories:

- orthognathic surgery;
- functional appliance;
- fixed appliance;
- removable appliance;
- headgear;
- anchorage reinforcement (TPA or Nance);
- extractions.

Table 1 Table showing the range of cases according to incisor relationship and IOTN score judged by three examiners

Case number	Incisor relationship	IOTN Dental Health component	IOTN Aesthetic component
01	Class I	4c	8
02	Class III	5i	6
03	Class II div 1	4c	7
04	Class II div 2	5i	4
05	Class III	4c	8
06	Class II div 1	5i	3
07	Class I	5i	6
08	Class III	4a	9
09	Class II div 2	3d	2
10	Class II div 1	5h	7
11	Class I	4c	9
12	Class II div 2	4c	7
13	Class 1	5a	9
14	Class III	4c	8
15	Class I	4c	8
16	Class III	4c	6
17	Class I	5a	8
18	Class II div 2	4d	8
19	Class II div 1	5i	7
20	Class III	4c	6

The data for each orthodontist were analysed, using the kappa statistic, for:

- intra-examiner agreement between the two hand-held cast assessments (H1 *v.* H2);
- intra-examiner agreement between the first set of hand-held casts compared with the articulated casts (H1 *v.* A1).

The median kappa statistic for each decision was calculated and the 95 per cent confidence intervals. Levels of agreement were judged according to the criteria of Landis and Koch.[11] The differences between the kappa statistics for H1 *v.* H2 and H1 *v.* A1 were tested with the Wilcoxon matched pairs signed rank sum test, which is the non-parametric equivalent of the paired *t*-test.

Results

The mean age of the orthodontists was 34.5 years with a range of 31–45 years and a standard deviation of 4.6 years. The minimum time since completion of orthodontic training was 6 months and the maximum was 15 years with a mean of 4.2 years. The orthodontists were trained at five different orthodontic units in the UK.

The median kappas and 95 per cent confidence intervals for the seven decisions of H1 *v*. H2 and H1 *v*. A1 are shown in Table 2. The medians are for the 20 cases assessed by 10 clinicians. There was almost perfect agreement within and between clinicians on the need for fixed appliances for all the cases. Very few removable appliances were used. Agreement with the use of functional appliances was substantial for both H1 v H2 (1.00) and H1 v A1 (0.91), reflecting the small number of cases considered in need of a functional.

The median kappa for the decision whether or not to extract showed substantial agreement for H1 *v*. H2 (0.73) and moderate agreement (0.55) for H1 *v*. A1. This was significantly different ($P = 0.007$). To examine whether clinicians were more or less likely to extract with the hand-held compared with articulated models a cross-table of decisions was examined. This showed that for 161 out of the 200 decisions there was agreement on whether to extract or not between H1 and A1. Of the disagreements, on 17 occasions the clinician decided to extract with the hand-held, but not with the articulated models and on 22 occasions this was reversed. Examination of the raw data did not show a trend either way with any specific cases.

The median kappa for the decision whether or not to use headgear showed moderate agreement (0.48) for H1 *v*. H2 and fair agreement (0.21) for H1 *v*. A1. This difference was not statistically significant ($P = 0.674$). Similar kappa statistics are shown for the decision to use anchorage reinforcement or not (0.50 and 0.32). Overall, there was good agreement between hand-held and articulated with no changes of decision in 160 out of the 200 decisions for headgear and 150 decisions for the anchorage reinforcement. It was noticeable how little headgear was used. Nearly three-quarters of decisions with both hand-held and articulated agreed that no headgear was required. One individual did not use headgear at all with H1 or H2 and one individual did not use headgear with H2.

The median kappa for the decision whether or not to prescribe orthognathic surgery showed substantial agreement (0.83) for H1 *v*. H2 and moderate agreement (0.48) for H1 *v*. A1. This difference was not statistically significant ($P = 0.093$). Examination of the cross-table for the surgical decision showed that in 169 out of 200 decisions there was agreement between hand-held and articulated models. There was an almost equal change in decision between the hand-held and the articulated assessments with 18 decisions advocating no surgery with the hand-helds, but changing to surgery with the articulated models and 13 *vice versa*.

Discussion

Our most important finding was that articulation did not meaningfully influence treatment decisions. It therefore appears that routine articulation of all study models is unnecessary.

The aim of this study was to assess whether the articulation of casts in CR would affect the treatment planning decisions of practicing orthodontists. It was therefore the change in the decision by each examiner between H1 *v*. H2 and H1 *v*. A1 that was of interest, i.e. the intra-examiner agreement, not the inter-examiner agreement. The assumption was made that the change would be due to articulation of the models. Unfortunately, it has been shown that treatment planning by one individual on the same set of records can lead to considerable variation,[8,9] so this cannot be guaranteed. However, examination of the individual intra-examiner kappa statistics for the two decisions about extraction and orthognathic surgery shows a very similar range of

Table 2 Kappa statistic median values and 95 per cent confidence intervals for the median for the seven decisions made on 20 cases by 10 individuals. *P* is the differences between the two hand-held assessments (H1 *v.* H2) and the first hand-held and articulated assessments (H1 *v*. A1) tested with a Wilcoxon signed rank test

	Hand *v*. Hand (H1 *v*. H2)			Hand *v*. Articulated (H1 *v*. A1)			
Decision	Median kappa	LCI	UCI	Median kappa	LCI	UCI	*P*
Extraction	0.73	0.48	0.89	0.55	0.31	0.73	0.007
Headgear	0.48	0.06	1.00	0.21	-0.08	0.77	0.674
Anchorage	0.50	0.19	0.68	0.32	0.13	0.68	0.721
Functional	1.00	0.46	1.00	0.91	0.46	1.00	0.462
Surgery	0.83	0.35	1.00	0.48	0.36	0.69	0.093
Removable	0.64	0.32	1.00	1.00	-0.08	1.00	0.655
Fixed	1.00	1.00	1.00	1.00	1.00	1.00	0.317

scores to that of Lee *et al.*[9] It would seem that our clinicians were not more or less inconsistent than other clinicians and reasonable to assume that any additional inconsistency between H1 *v.* A1 is due to articulation.

A number of the orthodontists taking part in this study were young and had recently completed orthodontic training. It is possible younger clinicians could be less consistent when treatment planning. However, comparison of intra-examiner kappa scores with those of Lee *et al* [9], who used older orthodontists (mean age 44 years) with a range since post-specialty qualification of 6–32 years, showed similar scores.

The sample of consecutive cases was chosen to represent a typical caseload in a UK District General Hospital. Criticism could be made against the decision to include multi-disciplinary cases, rather than orthodontic cases only. The inclusion of multi-disciplinary cases, for example, hypodontia cases, may have influenced some decisions made, e.g. whether or not to extract teeth. However, we felt that selection of cases for inclusion might have introduced bias into the study and preferred to use cases consecutively commencing treatment. The size of the sample could also be criticized. Lee *et al.*[9] involved 10 clinicians who examined 60 cases on two occasions, 30 days apart. This study also included 10 clinicians who examined 20 cases, but over three occasions. Use of articulators considerably increased the bulk of the material and the time taken to examine the cases. The number was chosen to reduce the practical limitations of distributing large quantities of articulated material between clinicians and minimizing the assessor fatigue of examining large numbers of cases. Individual intra-examiner kappa scores were similar between this investigation and that of Lee *et al.*[9] and suggests that a larger sample of cases would not change the results substantially.

The only statistically significant change in the kappa score between H1 *v.* H2 and H1 *v.* A1 was for the extraction decision. However, further examination of the change in decision between the hand-held and articulated models showed no consistent pattern indicating that clinicians were no more or less likely to extract with articulated models. Lee *et al.*[9] found that clinicians were more likely to prefer extraction when the lower incisors were proclined. The angulation of the lower incisors would not be affected by articulation of the models.

There was no statistically significant change in the decision to opt for orthognathic surgery between the hand-held and articulated models. Closer examination of the specific cases suggested that a clinician was less likely to advocate orthognathic surgery in a Class III case with articulated models than with hand-helds and more likely to opt for surgery with articulated models in Class II cases. This may signify that clinicians are carrying out their treatment planning mainly from the study models as found by Han *et al.*[7], rather than facial appearance or the cephalometric values, which did not change between the hand-held and articulated examinations. This assertion needs to be taken with caution as the work is limited by the use of photographs and may change if the patient was present. Further work with selected samples of Class II and III is required to determine if articulation is helpful for certain malocclusions.

The intra-examiner agreement for the articulated models was not examined during this study. It was felt that after three examinations of the same case there was a danger of familiarity, which may affect the results. It would be interesting to see if articulation of models leads to more consistent treatment planning decisions.

Difficulties in recording centric relation

There are difficulties in both achieving and recording a centric relation. Roth[2–4] does not believe that CR can be recorded unless the patient has undergone a period of splinting for at least 3 months before diagnostic records are taken, whilst Wood *et al.*[10] suggest that it may be impractical to place every patient in a CR splint. Instead, they advocate Roth's 'two piece power centric relation registration' in those patients without temporomandibular joint problems prior to treatment.

The reproducibility of CR recordings has been examined by a number of authors and may vary according to the method and material used.[12–17] Reproducibility is often poor and can vary with the manner in which the mandible is guided into CR[12,13,16] the material used.[14,15] In this study, a single operator (author PE) made all the CR and ICP recordings. There was no period of splinting before records were taken as no patients reported temporomandibular problems. There is, therefore, a possibility that the bite was not recorded in true centric relation, this is accepted as a possible limitation of the methodology. However, one study[18] found that 81 per cent of potential orthodontic patients did not have a significant CR-ICP discrepancy and, hence, there would be little difference between hand-held and articulated casts. Although this publication generated considerable debate.[19,20]

There are also potential errors in mounting the articulated casts that may be caused by flexibility of the face-

bow during mounting or expansion of the mounting plaster on setting. This led Clarke *et al.*[21] to conclude that 'the many stages involved in mounting models on a semi-adjustable articulator is a potential source of error and that only if the technique is carried out with a high degree of accuracy is it worth the additional chairside time'. In this study the same technician mounted all casts, supporting the facebow during mounting and using techniques to minimize expansion. In addition, all duplicated casts were carefully checked using the original inter-occlusal bite to ensure the occlusal contacts were accurately reproduced.

The results of this study are valid only for the sample examined. This study may be repeated using larger sample size in order to generalize the findings to all orthodontic patients. In addition it may be useful to examine specific subgroups of patients i.e. Class II, Class III, anterior open bite, orthognathic, hypodontia or high angle cases, to see if the information gained from articulation is indicated in specific malocclusion types.

Conclusions

- Routine articulation of study models for all orthodontic patients is not supported by the results of this study.
- Articulation of the study models of 20 orthodontic patients did not affect the treatment planning decisions of 10 UK orthodontists compared with handhelds in a meaningful manner.
- Further work with selected samples is required to determine if articulation is helpful for specific malocclusions.

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