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The effect of a Clark twin block on mandibular motion: a case report

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Aims: To investigate mandibular motion in six degrees of freedom before, during and after twin block treatment in one individual.

Methods: The appliance was worn for eight months, and motion recordings, using a 12-camera opto-electric system, were captured prior to placement of a twin block appliance and 2, 4, 14 and 52 weeks after insertion.

Results: The wide variations in mandibular motion that accompany twin block wear disappeared post-treatment, except for an increase in anteroposterior movement of the mandible.

Conclusion: Twin block therapy appears to affect mandibular motion temporarily.

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Introduction

Movement of the mandible has been investigated and documented for over a century,[1] and as technology advanced, so has our ability to accurately capture mandibular motion in three planes of space. Of late, magnetic and opto-electric camera systems have been employed to track human movement, including the translation and rotation of the mandible in the three planes of space.[2–6] In dentistry, kinematic studies have been used to investigate normal jaw physiology and function,[7–10] and the changes associated with temporomandibular dysfunction[11,12] and orthognathic surgery.[13–15] To our knowledge no studies have examined condylar motion in patients using functional appliances.

Functional appliances, including the design popularised by William Clark,[16] are used to treat Class II malocclusions characterised by mandibular retrognathia. The dentoalveolar effects of functional appliances are well-documented,[17] but there is less certainty of their effects on the condyle and the articulating surface. Primate studies have indicated that there is some remodelling of the condylar heads in a posterior direction and that the glenoid fossae are remodelled by a combination of bone deposition posteriorly and resorption anteriorly.[18,19] Furthermore, there is evidence to suggest that the retrodiscal tissue becomes increasingly vascularised during prolonged mandibular advancement,[20] indicating an inflammatory response in that region. Whilst these changes have not been confirmed in human subjects, we postulate that local adaptations within the human condylar joint during anterior posturing of the mandible may produce functional changes in mandibular kinematics.

The aim of this study was to describe the mandibular motion in an individual undergoing growth modification orthodontic treatment using a Clark twin block appliance.

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Figure 1. Pretreatment intra-oral photographs.

Figure 2. A model showing the arrangement of reflective markers attached to the cranial cap, the lateral pole of the right condyle and the splint.

Methods

An 11 year-old male subject with a Class II division 1 malocclusion and a retrusive mandible was referred to the Orthodontic Clinic, University of Otago. The ANB angle was 10 degrees and the Wits value was +9 mm. The pretreatment intra-oral photographs of the subject are shown in Figure 1. The study was approved by the University of Otago Human Ethics Committee and informed consent was obtained for the mandibular motion study.

The proposed intervention consisted of two phases: a twin block appliance followed by fixed appliances. The twin block appliance, which incorporated an upper labial bow to retract the upper incisors, was relieved to allow exfoliation of the remaining deciduous canines and molars and eruption of the permanent molars. The method of capturing mandibular motion was similar to that described previously.[12] Briefly, a vacuum-formed occlusal splint was fabricated to fit the subject's lower dentition, to which was attached a wire frame that supported seven reflective markers: three anterior and two on each side. A new splint was manufactured for each recording to accommodate teeth that may have moved in the interim.

Six cranial reference markers were attached to a tight fitting latex swim cap worn by the subject and two markers were placed over the condylar heads, determined by palpation (Figure 2). Motion was captured using a 12 camera infra-red Motion Analysis System (Motion Analysis Corporation, Santa Rosa, CA, USA) at a sampling rate of 60 Hz and supported by EvaRT 4.0 software (Motion Analysis Corporation).

Recordings of condylar motion were made prior to twin block therapy, after 2, 4 and 14 weeks treatment, and 12 months from the start of treatment. The subject was instructed to wear the twin block appliance full-time, although compliance was not monitored. He was treated for 8 months and during this time the overjet reduced from 11 mm to 3 mm (Figure 3). At the end of this phase of treatment a modified Hawley retainer with a lower anterior bite plane was fitted. The subject declined the second phase of fixed appliance treatment.

At each recording, the subject was orientated in a natural head position and the static position (with the teeth in maximum intercuspation) recorded for 6 seconds. He was then asked to perform a comfortable open and closing movement of his mouth within a 6-second time frame and this was repeated six times at each recording. A custom-written programme was then used to identify the opening and closing parts of each recording and each cycle was normalised to 100 points.

During the 6-second static recording the mandibular (MP) and cranial (CP) axes were located while the jaw was closed (Figure 4). The origin of the mandibular axes (MP) was located at the midpoints of markers overlying the right and left condyles. An orthogonal axes system was then constructed with the Z-axis passing through MP and the midpoint of the jaw device, and the X-axis passing through the left and right condylar markers. The Y-axis was perpendicular to the X- and Z-axes. Similarly, the origins of the cranial axes (CP) were located at the midpoints of the left and right temporal markers. A second orthogonal axes system was then constructed with Z-axis passing through CP and the frontal head marker, and the X-axis passing through the left and right temporal markers. The local coordinates of all mandibular and cranial markers were then calculated with respect to

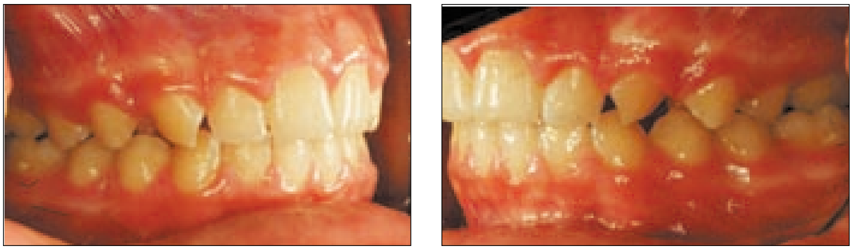

Figure 3. Intra-oral photographs after 8 months treatment.

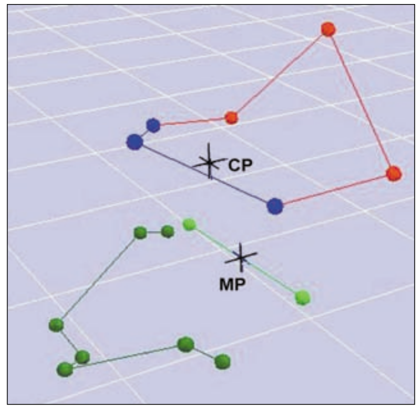

Figure 4. The cranial global axes (CP) and mandibular global axes (MP) are calculated from the cranial and mandibular markers, respectively.

Table I. Mean differences (95% CI) between the mean maximum rotation pretreatment and the four post-insertion recordings in the X, Y and Z axes.

Rotation (degrees)	Post-insertion 2 weeks Mean (95% CI)	Post-insertion 4 weeks Mean (95% CI)	Post-insertion 14 weeks Mean (95% CI)	Post-insertion 12 months Mean (95% CI)
X	3.60 (0.92, 6.28)*	1.46 (-1.33, 4.27)	8.09 (5.42, 10.77)**	8.08 (5.26, 10.87)**
Y	0.17 (-0.64, 0.417)	-5.05 (-5.30, 4.79)**	-5.16 (-5.40, 4.92)**	-2.16 (-2.41, 1.91)**
Z	-0.65 (-1.19, -0.09)*	4.07 (3.49, 4.65)**	1.70 (0.59, 1.75) **	-0.84 (-1.23, -.045)**

ANOVA, * $p < 0.05$, ** $p < 0.01$

each axes system. During the movement trials, the mandibular and cranial axes were reconstructed from local and global coordinates of the corresponding markers using a least squares fitting procedure. The relative rotation and translation between the MP and the CP were calculated in degrees and millimetres respectively along three axes: X, left-right; Y, vertical; Z, anteroposterior (Figure 5).

The error of detection of an individual reflective marker by the camera under dynamic conditions was less than 0.4 mm, which is considered insignificant with respect to the total movement recorded by the two points. The error in rotation within and between the recording sessions had previously been calculated by Johnson et al. as less than 1 degree.[12]

Statistical analysis

A one-way analysis of variance (ANOVA) was used to compare the mean differences in the dependent variables of mean maximum rotation (degrees) and mean maximum translation (mm) between the pretreatment and the four post-insertion recordings (the last being the post-treatment 12-month recording).

Results

The results were based on the means of six repeat measures during each recording session with the exception of the 4-week and 12-month recordings, where on both occasions the results of one of the six measures was discarded due to technical difficulties. The mean rotation data about each of the three axes and the mean translation data for the pretreatment and final (12-month) recordings are shown in Figure 6.

Statistically significant differences were found between the mean maximum rotation pretreatment and the 2-week, 14-week and 12-month recordings in the X-axis, between the mean maximum rotation pretreatment and the 4-week, 14-week and 12-month recordings in the Y-axis, and between the mean maximum rotation pretreatment and the 2-week, 4-week, 14-week and 12-month in the Z-axis (Table I).

Significant differences were also found between the mean maximum translation pretreatment and the 2-week, 14-week and 12-month recordings in the X-axis, between the mean maximum rotation pretreatment and the post-insertion recordings in the Y-axis

Table II. Mean differences (95% CI) between the mean maximum translation pretreatment and the four post-insertion in the X, Y and Z axes.

Translation (mm)	Post-insertion 2 weeks	Post-insertion 4 weeks	Post-insertion 14 weeks	Post-insertion 12 months
X	1.06 (0.61, 1.51)**	-0.39 (-0.86, 0.08)	1.10 (0.63, 1.58)**	-0.88 (-1.35, -0.40)**
Y	-5.11 (-6.98, 3.24)**	-8.40 (-10.36, -0.17)*	-2.12 (-4.08, 1.06)	-0.88 (-2.84, 1.06)**
Z	2.09 (0.98, 3.20)**	-8.78 (-9.94, 7.62)**	6.42 (5.26, 7.58)**	6.52 (5.36, 7.68)**

ANOVA, * $p < 0.05$, ** $p < 0.01$

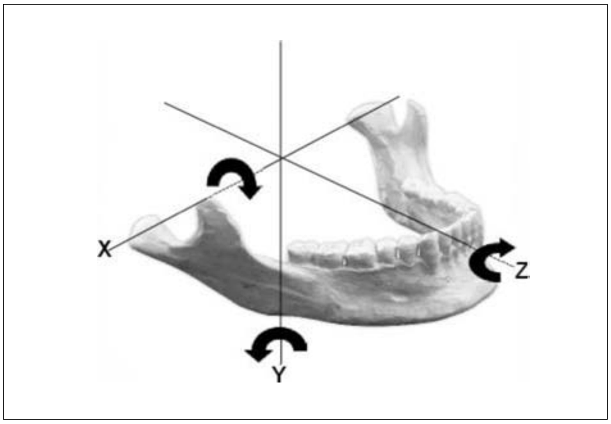

Figure 5. The axes and planes of mandibular movement. In this model the centre of the mandible is the midpoint of the condylar markers.

at 2-weeks, 4-weeks and 12-months, and between the mean maximum pretreatment translation and all post-insertion values (Table II).

Discussion

Although not specifically assessed using a clinical outcome measure such as the PAR Index,[21] there was an overall improvement in the occlusion at the end of phase one treatment, which suggests that compliance was adequate (Figures 1 and 3).

The kinematic model used in this study reduces mandibular motion to a single 'condyle equivalent', a point situated midway between the lateral poles of the right and left condyles, referred to as MP. The kinematics of this point were tracked relative to a static reference point, midway between the stable cranial markers (CP). The system can accurately track relative movement between these points with six degrees of freedom, but it is unable to locate the starting position of MP relative to anatomical cranial structures. The assumption made in previous kinematic studies is that condylar movement begins at the resting position when teeth are in contact, which can approximate, but not necessarily coincide with centric relation. Centric relation has been loosely defined as the position when the condyles are in their most anterosuperior positions against the slopes of the articular eminences.[22] The method of determining condylar position by palpation has been criticised in the past because it is subjective, and has a location error that can vary up to 5 mm.[23] We attempted to limit errors in location by using the same operator to locate the points in one subject. It has also been shown that the overall pattern of jaw movement is the same despite variations in location of the condyles, although some differences in the shape of the path of jaw motion can be expected.[24] In our study, the use of a single representative point, located between the condyles, further reduced any error due to inaccurate marker placement over a condyle.

In patients undergoing twin block therapy, the condyles may not necessarily be in centric relation as the mandible is encouraged to posture anteriorly. Figure 7 shows the approximate tracking of point MP over the five recordings in the anteroposterior and superior-inferior planes, relative to the automatic origin generated at each recording and with approximate envelopes of error. Minimal variation in mandibular opening occurred at the pretreatment and 2-week recordings, although a slightly greater opening was observed after two weeks of appliance wear. The 4-week recording was statistically different from the two initial recordings: MP was positioned more posteriorly and inferiorly than initially.

A possible explanation for this difference is that the condyle started from a more anterior position as a result of posturing, and in order to achieve opening, the condyles had to move in a posterior direction relative to CP. Mandibular motion in both planes was very variable, as indicated by the large standard deviations. Furthermore, absolute opening was

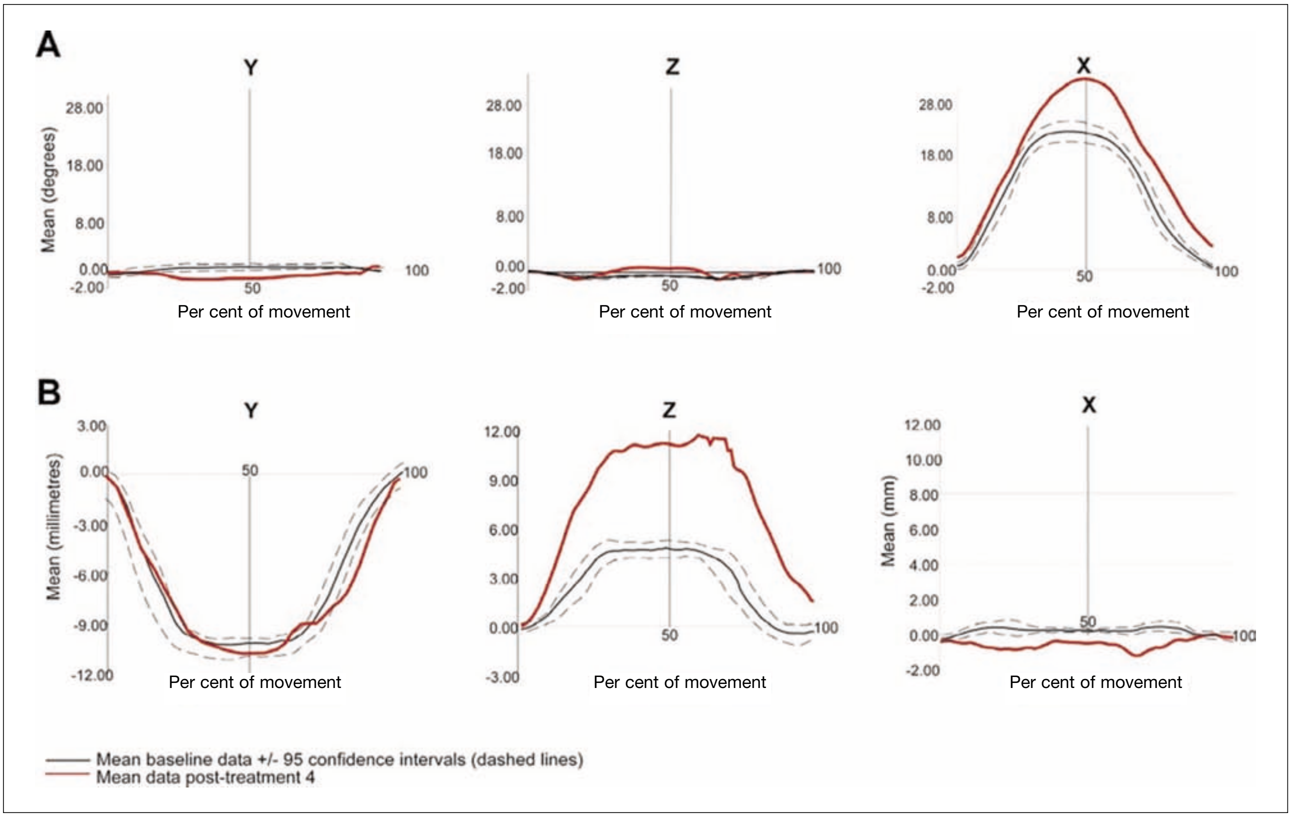

Figure 6. Graphs depicting the mean rotation (A) and translation (B) (dashed lines, ± 95% CI) in the X, Y and Z planes. Each line is based on six repetitive trials from the pretreatment and post-treatment sessions.

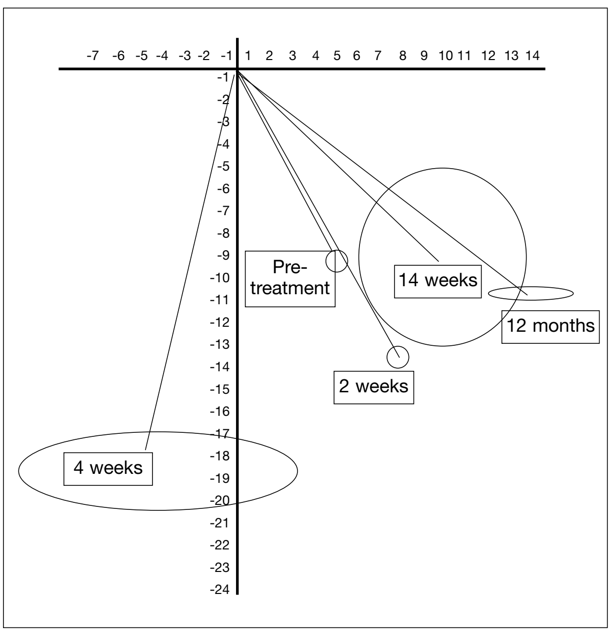

Figure 7. Trajectories of MP in the anterior-posterior and superior-inferior planes at the initial and four post-insertion recordings, together with the standard deviation envelopes (not to scale).

approximately double the initial value, although this may be partly due to a training effect, despite measures taken to minimise this. The 14-week recordings indicated that MP moved anterior-inferiorly, although this was also accompanied by large variability in jaw kinematics in both the A-P and the superior-inferior planes. The final recording at the end of treatment (12 months) shows that mandibular motion became more consistent in the vertical plane, with average opening values similar to those obtained at the first recording. Point MP translated anteriorly approximately two and a half times more than in the initial recording, with more variation in the horizontal plane. Table I indicates significant rotation within the mandible between the initial and final recordings (approximately 8 degrees), but this may not have clinical significance. The results indicate that mandibular opening and closing during twin block therapy undergo a phase of dramatic fluctuation, accompanied by forward posturing, but these return to a more consistent motion post-treatment that largely resembles the pretreatment pattern, except for a greater anteroposterior movement.

Conclusions

During treatment the twin block appliance changed mandibular function from the usual anterior movement on opening to a distal movement of the mandible. Mandibular movement during therapy was very variable, but these changes largely disappeared after removal of the appliance: the condylar trajectories tended to return to the pretreatment curves.

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References

1. Luce CE. The movements of the lower jaw. Boston M Surg J 1889;121:8–11.
2. Mongini F, Tempia-Valenta G. A graphic and statistical analysis of the chewing movements in function and dysfunction. J Craniomandibular Pract 1984;2:125–34.
3. Mesqui F, Palla S. Real-time non-invasive recording and display of functional jaw movements. J Oral Rehabil 1985;12:541–2.
4. Proeschel P. An extensive classification of chewing patterns in the frontal plane. Cranio 1987;5:55–63.
5. Airoldi R, Gallo LM, Palla S. Precision of the jaw tracking system JAWS-3D. J Orofac Pain 1994;8:155–64.
6. Naeije M, Van der Weijden JJ, Megens CC. OKAS –3D: an opto-electric jaw movement analysis system with six degrees of freedom. Med Biol Eng Comput 1995;33:683–8.
7. Zafar H, Nordh E, Eriksson PO. Temporal coordination between mandibular and head-neck movements during jaw opening-closing tasks in man. Arch Oral Biol 2000:45;675–82.
8. Gallo LM, Fushima K, Palla S. Mandibular helical axis pathways during mastication. J Dent Res 2000:79;1566–72.
9. Lewis RP, Buschang PH, Throckmorton GS. Sex differences in mandibular movements during opening and closing. Am J Orthod Dentofacial Orthop 2001:120;294–303.
10. Proeschel PA. Chewing patterns in subjects with normal occlusion and with malocclusions. Semin Orthod 2006:12;138–49.
11. Miyawaki S, Tanimoto Y, Inoue M, Sugawara Y, Fujiki T, Takano-Yamamoto T. Condylar motion in patients with reduced anterior disk displacement. J Dent Res 2001:80;1430–5.
12. Johnson GM, Coe H, Wirawan R, Wong L, Lee C, MacFadyen E. Objective discrimination between mandibular open/close excursion patterns: a clinical case report. Cranio 2007:25;218–24.
13. Athanasiou AE. Electrognathographic patterns of mandibular motion after bilateral vertical ramus setback osteotomy. Int J Adult Orthodon Orthognath Surg 1992:7;23–9.
14. Ehmer U, Broll P. Mandibular border movements and masticatory patterns before and after orthognathic surgery. Int J Adult Orthodon Orthognath Surg 1992:7;153–9.
15. Throckmorton GS, Ellis E. Recovery of mandibular motion after closed and open treatment of unilateral mandibular condylar process fractures. Int J Oral Maxillofac Surg 2000:29;421–7.
16. Clark WJ. Twin block functional therapy. 1995. Mosby-Wolfe, Turin, Italy.
17. Dermaut LR, Aelbers CMF. Orthopedics in orthodontics: fiction or reality. A review of the literature – Part II. Am J Orthod Dentofacial Orthop 1996:110;667–71.
18. Adams CD, Meikle MC, Norwick KW, Turpin DL. Dentofacial remodelling produced by intermaxillary forces in Macaca mulatta. Arch Oral Biol 1972:17;1519–35.
19. McNamara JA, Carlson DS. Quantitative analysis of temporomandibular joint adaptations to protrusive function. Am J Orthod 1979:76;593–611.
20. Woodside DG, Metaxas A, Altuna G. The influence of functional appliance therapy on glenoid fossa remodelling. Am J Orthod Dentofacial Orthop 1987:92;181–98.
21. Richmond S, Shaw WC, O'Brien KD, Buchanan IB, Jones R, Stephens CD et al. The development of the PAR index (Peer Assessment Rating): reliability and validity. Eur J Orthod 1992:14;125–39.
22. Rinchuse DJ, Kandasamy S. Centric relation: a historical and contemporary orthodontic perspective. J Am Dent Assoc 2006;137:494–501.
23. Zwinjenburg A, Megens CC, Naeije M. Influence of choice of reference point on the condylar movement paths during mandibular movements. J Oral Rehab 1996:23;832–7.
24. Ostry DJ, Munhall KG. Control of jaw orientation and position in mastication and speech. J Neurophysiol 1994:71;1528–45.