Comparative Study and Analysis of Mandibular Movements Utilizing Dynamic Recording Systems

Ralph E. Podesta, DDS, Ryle A. Radke Jr, DDS, Frederick D. Fullmer, DDS, MS, Jon C. Karna, DDS, Angelo Cacciatore, AB, DDS, Richard A. Gaebel, DDS, Thomas W. Wood Jr, DDS

Introduction

This comparative study was undertaken to detect the clinical characteristics of electronic and mechanical mandibular recording systems, and to determine if any of these characteristics would aid the clinician in selecting one instrument over another for treatment planning.

Four systems readily available to the profession were selected: two electronic axiographs, a mechanical pantograph, and a functionally generated path. All four recording devices were used on each of the following three patients:

- Patient #1 has a history of bruxism with bilateral working balance and no clinical symptoms.
- Patient #2 has a history of temporomandibular dysfunction (TMD), shows anterior disclusion with posterior interferences on the balancing sides bilaterally, and has clicking joints with occasional pain and edema in the left joint.
- Patient #3 has well defined anterior guidance, shows posterior disclusion, and no clinical symptoms.

Utilizing computer software, these recordings were plotted to allow direct comparison of the graphed data.

It must be noted that no treatment was rendered on any of the patients in this study. No splint therapy was provided either before or after recording.

Three types of clutches were used: para-occlusal, tray type, and central bearing pin. A study by Alasawaf and Garlado\(^1\) showed no evidence that a change in vertical dimension due to inter-arch tooth guidance or the use of a clutch caused any significant alteration in the recordings of condylar path travel.

Materials and Methods

The mandibular border movements of each patient were recorded twice on the following mandibular recording systems:

- The SAM (Slavicek and Mach) electronic axiograph (Gamma Institute USA, Rochester, NY)\(^2\)–4
- The SAS (Scharnier-Achs-Schreibsystem) Hinge Axis Tracing System (Vertrieb, Munich, Germany)\(^5\)–6
- The Stuart mechanical pantograph (Stuart Articulators, Ventura, CA)\(^7\)–8
- The TMJ functionally generated path analogue articulator (TMJ Instrument Company, Santa Ana, CA)\(^9\)–13

The recordings were stored using CADIAX computer-aided axiograph software (University of Vienna, Austria),\(^14\) and became the reference database (Fig 1).

Recordings were both guided and unguided. Guidance was unstrained. The mandible was guided from centric relation through the various functional excursions. Sufficient superior pressure was used to maintain condylar juxtaposition to the glenoid.
fossa during guided movements. One experienced operator manipulated the patients, who were seated upright. Unguided excursions involved no operator influence. All three patients were dentists who comprehended verbal instructions for mandibular movements.

After the patients were recorded, the SAM, Stuart, and TMJ fully adjustable articulators were programmed. The SAS Hinge Axis Tracing System was used to program a SAM II articulator (Great Lakes Orthodontics, Tonawanda, NY). The SAM electronic axiograph was oriented to each of the programmed articulators (Figs 2 to 4).

The articulators were guided through their border movements and the mandibular movements of the three programmed articulators were recorded by the SAM electronic axiograph (Fig 5). This allowed direct comparison of the three programmed articulators, as well as their relationship to the SAM electronic axiographic recordings of the patients.

The SAM electronic axiograph stored the articulator movements using CADIAx computer software to create a reference database. Using this database, the protrusive and right and left lateral (mediotrusive) movements were plotted on transparencies. These transparencies represented the recordings of the articulators for each patient. They also included the patients’ mandibular movements recorded directly on the SAM electronic axiograph. From the transparencies, using an overlay technique, a single superimposed graph was generated for right lateral, left lateral, and protrusive movements for each patient.

Figures 6 through 8 are superimposed recordings that have been computer-enhanced for clarity. In the illustrations of the recordings, the systems are color coded: black is the SAM, blue is the SAS, green is the Stuart, and red is the TMJ. Figure 6 shows an example of a direct comparison of a protrusive movement of the left condyle with each
of the four recording systems. Figures 7a, 7b, and 7c are of one patient, guided. Figures 8a, 8b, and 8c are of one patient, unguided. The accuracy of the SAM electronic axiograph and CADIAx software was established with the Temporo-Mandibular-Positions-Comparators (TMPC) instrument in collaboration with Drs Lotzmann and Scherer of the University of Göttingen, Germany. The accuracy was confirmed in two Göttingen studies at 94%, within .01 mm (Figs 9 and 10).
Results

The Sagittal View

The Stuart articulator recordings produced the steepest horizontal condylar inclinations (HCI). The TMJ produced the flattest. The SAS and the SAM were similar to each other, between the two extremes. In one patient, the TMJ HCI recording was equal to the SAS and SAM HCIs. Variances in the HCIs from low to high were 10 to 70 degrees with a mean of 30 degrees.

The Coronal View

In our sample, the TMJ articulator recordings tended to have the lowest Bennett angles. The SAS and Stuart recordings showed higher and similar Bennett angles, while the SAM electronic axiograph recordings were midrange and closer to the TMJ. The SAM II articulator, the Stuart articulator, and the SAM electronic axiograph (the patients' recordings) were grouped within 20 degrees of one another. The TMJ tracked closest to the anteroposterior axis.
Fig 7a  Left lateral excursion, guided.

Fig 7b  Right lateral excursion, guided.

Fig 7c  Protrusive-retrusive movement, guided.
Fig 8a  Left lateral excursion, unguided.

Fig 8b  Right lateral excursion, unguided.

Fig 8c  Protrusive-retrusive movement, unguided.
Conclusions

This comparative study illustrates that some recording devices have characteristics that might lend themselves to preferred treatment. Using the three patients as examples:

- Patient #1 with bruxism – Dynamic recording devices such as the TMJ instrument might offer some advantage over the more passive systems. Patients with heavy musculature displaying destructive parafunctional activity may best be recorded on a dynamic recording system with its resulting analogue. These systems require the patients to functionally generate their recordings. They provide loading of the stomatognathic system.

- Patient #2 with TMD – Patients with TMD symptoms may be best served with a more passive and less stressful recording system, such as the SAM, following TMD therapy.

- Patient #3 with normal occlusion and no clinical symptoms – Any one of the instruments would have the potential for satisfactory clinical results. More study is needed to explain why functionally generated analogues showed the lowest HCls and the lowest Bennett angles. Loading of the temporomandibular joint with its articulator disc may partially explain these findings. The findings of the study suggest that the selection of a recording system should be based on its unique compatibility to the individual patient.
Fig 9b  Graph demonstrating the accuracy of the SAM electronic axiograph as measured by the TMPC for the Göttingen study. The x-axis shows anteroposterior relationships, while the z-axis is for superior-inferior measurements.

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References

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Fig 10  Graph demonstrating the accuracy of the SAM electronic axiograph as measured by the TMPC for both the San Francisco (SF) and the Göttingen (Gö) studies. The y-axis shows the horizontal condylar relationship.


Address:
Dr Frederick D. Fullmer, Dept of Growth and Development
Drs Ralph E. Podesta, Jon C. Karna, Angelo Cacciatore, Richard A. Gaebel, Thomas W. Wood, Jr, Dept of Restorative Dentistry
School of Dentistry,
University of California at San Francisco,
San Francisco, CA 94143

Reprint requests:
Dr Ryle A. Radke, Jr, Dept of Fixed Prosthodontics,
School of Dentistry,
University of The Pacific School of Dentistry
2155 Webster St.
San Francisco, CA 94115