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An evidence-based guide to occlusion and articulation.

Part 6: Artificial jaws: articulators real and imagined

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CP Owen[1]

SUMMARY AND PREAMBLE TO THE SERIES

Although this is essentially a review, it has not been written in the passive, third-person style normally associated with scientific writing, as it is intended to be thought-provoking and, hopefully, educational. It has therefore been written in more of a conversational style, and is aimed at students, dentists and dental technicians who are receptive to a slightly different view of occlusion and articulation, based on evidence.

Occlusion is a topic that has become a kind of archaic minefield of conflicting ideas, propositions, and above all, solutions, most of which are based on a complete lack of understanding of the evolution and development of teeth, and by extension, of clinically objective evidence.

That in itself is a statement of conflict (and perhaps even heretical), but it is by way of warning that this guide is not going to be much like anything you will find in standard text-books of dentistry or dental technology. It is, rather, an attempt to help you navigate through what you will read elsewhere, in the hope that eventually you will find an understanding that you can live with. It will appear as a sequential series in 7 Parts.

Artificial jaws: articulators real and imagined

The history of attempts to reproduce jaw movement by mechanical means is a fascinating one, and started about 190 (!) years ago. The value of a mechanical device and its ability to reproduce jaw movements and therefore its applicability to the clinical environment is, after nearly 200 years, still being debated. And now in this digital age we find ourselves in the realm of virtual devices.

But we should begin at the beginning. This will not be a history lesson, as the history of articulation has been well written, and you are referred to a series of articles published since 2001 in the Journal of Prosthodontics, written mostly by Scaife and Engelmeier (there are many, so the references are not given here, but a PubMed search for "history of dental articulators" will reveal them all).

In the beginning there was the so-called "plaster articulator" which wasn't an articulator at all, but merely a means of seating the models in a consistent position relative to each other. There was no movement. Then there was the "barn door hinge", which provided a simple hinge movement (Fig. 1).

So that was the start, and if you read the development of articulators since then, you will see all sorts of weird and wonderful designs. Instead of going through those, because very few people are interested in that sort of thing, this paper will look at the three types of articulator most commonly used today. These are the hinge articulator, the average-value articulator, and the so-called semi-adjustable articulator with its variation of a non-arcon and arcon (see later) type of movement.

In the early 20th century, the theories behind articulator development were basically either based on condylar guidance and rotation, which became to be called the

Fig. 1. A "barn-door hinge" articulator from the 1840s. In the collection of the Museum of Health Care, Kingston, Ontario, Canada. https://mhc.andornot.com/en/permalink/artifact13495 Accessed May 2021

Author affiliations:
1. **Owen CP:** *BDS, MScDent, MChD, FCD(SA),* Professor Emeritus, Faculty of Health Sciences, University of the Witwatersrand Johannesburg, South Africa, ORCID: 0000-0002-9565-8010

Corresponding author: CP Owen
Professor Emeritus, Faculty of Health Sciences, University of the Witwatersrand Johannesburg, South Africa
Email: peter.owen@wits.ac.za
Cell: +27 83 679 2205

"condylar" or "anatomic" school; or were based on the way the teeth articulated, and a belief that this guided the mandible, and that planes created by the tooth arches were the only consideration, not the condyles. This came to be known as the "geometric," or "nonanatomic," school. From this latter, we still have the curves of Spee, Monson, Wilson, Hall, and the triangular planes of Bonwill and Balkwill. We will mention these in due course but if you have read the previous papers in this series you should by now I hope, have a healthy scepticism about this school of thought. Astonishingly, some of this nonsense is still taught today, not in its historic context (as it should be) but as a means, for example, of setting teeth in complete dentures as a purely mechanical exercise. It's almost as astonishing as the fact that hinge articulators are still used today, so let's get on with looking at these three main types.

The hinge articulator

A 'modern' version of a simple hinge articulator looks a bit like Fig. 2, but in reality has been around for decades.

Recognising that this was a straight hinge movement, variations appeared which allowed for the upper member to slide along an inclined plane (Fig. 3), but was still referred as a hinge articulator. You can, sadly, also buy these today and they are, sadly, in common use.

It is astonishing that these articulators are still used, because they bear no relationship whatsoever to any movement of the mandible other than that of a straight hinge movement. Of course a clinically perceived hinge-like movement is a useful one when there are no teeth, as it is mostly a repeatable movement, but usually guided by the clinician. We are not carnivores as we have seen and so the likelihood of making restorations that will not have any interference to mandibular movement on these articulators is practically impossible. This is because, even in a so-called hinge movement, these articulators bear no relationship to even a perceived hinge movement of the mandible (Fig. 4).

Fig. 2. A simple hinge "Plane Line" articulator.

Fig. 3. A brass hinge articulator that allows some movement of the upper member.

So apart from the fact that we do actually chew, if the vertical dimension is wrong, taking a new jaw registration may not help and re-articulating the models with a wax bite between the teeth will mean that both arches have to be repositioned, not just one.

So the message is clear: there can be only very few clinical circumstances where the use of any form of a hinge articulator is justified. Perhaps a small inlay on a molar where there is a posterior disclusion in protrusive and lateral movements may not be a problem for example. Fortunately, there are other articulators that will provide more versatility. The next of these is the average-value articulator.

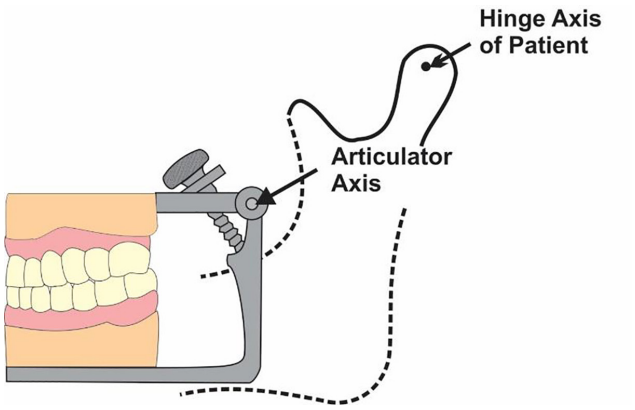

Fig. 4. The opening axis of a hinge articulator bears no relation to the opening axis of the mandible (if there is such a thing).

The average-value articulator

This is an articulator whose dimensions are closer to those of the skull, in that the distance between the condyles is (or should be) the average value of 110 mm. This, though, does not guarantee that the distance from the teeth to the axis of the articulator is the same as in the mandible so these too may have a similar limitation to the hinge articulator. Fig. 5 shows two types of these articulators. The one at the bottom has a posterior 'incisal pin' (arrow) which is very useful to maintain the vertical dimension when the incisal pin is removed for easier viewing of the anterior teeth.

Fig. 5. Two types of average-value articulator

Apart from the inter-condylar width, the other average settings are for the sagittal condylar guidance angle, which is set to 30° and the incisal angle which is set to 10°. These articulators have become very versatile since the evidence of anything much more complicated is now equivocal, but more of that later. Clearly there are still limitations, but the opening axis is likely to be similar to the clinically observed opening hinge-like movement of the mandible, and protrusive and lateral movements will provide some indication of how the teeth may relate to each other in these movements in the mouth. But certainly not completely, hence the search for the next layer of complexity, to try to relate the mandible's relationship to the skull in the same way as on the articulator. This led to the use of the facebow and the semi- or fully-adjustable articulators.

The facebow, semi- and fully-adjustable articulators.

Once again, the history of the development of the facebow and these ever more complex mechanical devices is (to some) a fascinating one, and the intention here is not to go into that or even into how they are used, but rather to concentrate on whether they should be used and under what circumstances.

First, though, a look at two generic articulator types, the 'arcon' and 'non-arcon' because these terms have been known to be confusing to some. The term, 'arcon' dates back to 1950 and is merely a contraction of the words articulator and condyle and was used to distinguish articulators which had the 'condyle' on the lower part and the 'fossa' on the upper part of the device. This was because many of the earlier articulators (which by the way, you can still buy today) had these parts the other way round and are now known as 'non-arcon'. An example is the Dentatus articulator (Fig. 6), and an arcon articulator, the Denar Mark II is shown in Fig. 7.

Fig. 6. A non-arcon articulator: the 'condyle is on the upper member and the 'fossa' on the lower member.

Fig. 7. An arcon articulator: the 'condyle is on the lower member and the 'fossa' on the upper member.

One of the advantages of the arcon type as shown, is that the entire upper member could be removed, which was very useful when, for example, waxing up full crowns. The dimensions of these articulators were also considered to be more natural when considered in relation to the head, or skull. The intention was to make the upper member coincide with Frankfort plane, and the condylar element to coincide with the mandibular condyles, or rather what was perceived to be the opening axis, or condylar 'transverse' axis or 'hinge' axis (Figs 8 and 9).

Fig. 9. Shows the articulator opening as if it were the mandible. In reality, the lower member remains flat on the bench and the upper member is opened, something that often confuses those using an articulator for the first time.

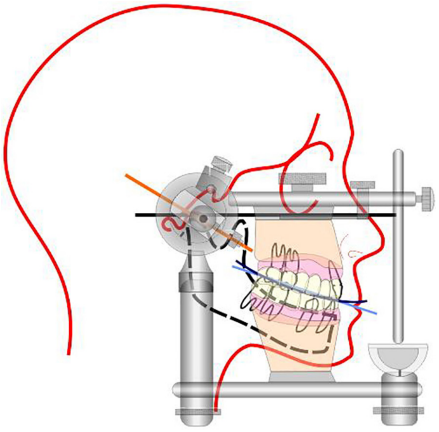

Fig. 8. An articulator (non-arcon) superimposed on the skull. The upper member was to coincide with Frankfort plane and the condylar element to coincide with the opening axis, so that the occlusal plane was at the correct height and angle.

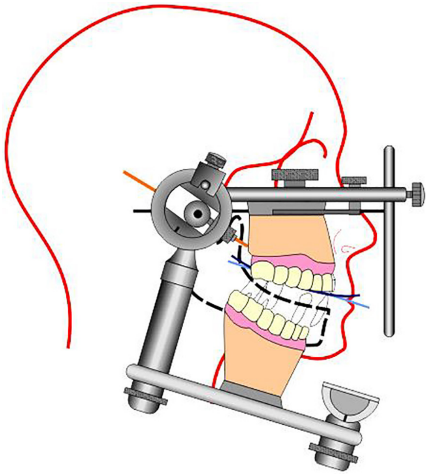

Fig. 9. The articulator opening as if it were the mandible.

In order to relate the real anatomical structures to the articulator, it was recognised early on that some other device was required, and the earliest recorded use (in 1889!) was of an "articulating caliper" which then evolved into the facebow, first described as such in about 1900.[1] Since then, all sorts of weird and wonderful devices have been used, but it is not the intention here to go onto these or how they are used. What is necessary to know and understand is what principles were being followed and if those principles bear any relationship to reality.

For that we need to go back to the anatomy of the system, because as we have said before, the temporomandibular joint is very complex and the mandible is only ever at rest when the teeth are firmly occluding. So the question must be asked: is it possible to reproduce the anatomy of the patient and the path of movement of the mandible from one position to the next? And sadly, the answer is in the negative, at least for now, as it may be possible to get closer in the digital world. In the analogue world, though, it is necessary to understand the limitations of mechanical devices, despite all the claims made by the manufacturers and such groups as the gnathologists.

And we have to go back to this 'hinge' axis, because of the assumption that it is a condylar axis, and on this assumption the kinematic facebow was created. This did indeed give the impression that the mandible was rotating, as a clutch attached to the mandibular teeth traced with a stylus against a vertical plate against the condyle would show a circular motion if the mandible was rotating on opening and closing as a 'hinge' (Fig. 10). The only problem is, as we have seen (in Part 1), that instantaneous centres of rotation exist and none of them are anywhere near a condylar axis.

Finding this kinematic axis was a time-consuming procedure, and so seldom done, and gave rise to the publication of many papers describing an "arbitrary" hinge axis and several methods of obtaining this. These have now evolved into probably the most common type of facebows in general use which uses one such arbitrary axis by relating it to the external auditory meatus and hence a facebow can be placed into the ear, which is must easier to use.

However, there are few studies comparing the effects of using these different facebows and so-called axes on the ease with which restorations are placed with or without occlusal adjustments once the restorations are placed in the only articulator that really matters – the patient. For some reason there have been attempts to relate the intercondylar axis as a guide to setting complete denture teeth [2] and there have been radiographic measurements on intercondylar width for no apparent reason other than to conclude that some people have larger mandibles than others! [3] But a seminal (and another which has largely been ignored: it has had only 14 citations in 19 years) study [4] did relate the effect of articulator setting to the estimated existence of any occlusal errors, and that is precisely

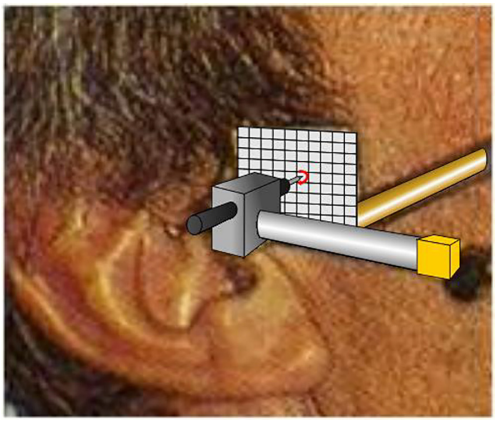

Fig. 10. A stylus attached to the lower component of a kinematic facebow will show a circular movement if the mandible purely rotates.

what we need to know to assess the limitations of such mechanical devices.

Although the paper used a kinematic axis and therefore rested on the assumption that this was true, by transferring data to a virtual articulator, the authors were able to derive average values for a number of parameters. These were interesting in the ranges and means that were produced from 57 subjects (the usual suspects: dental students) with complete dentitions and normal function. For example, the sagittal condylar guidance angle had a range of 36° to 71° with a mean of 53°; the medial condylar guidance angle had a range of -6° to 29° with a mean of 7°. But what was important, was that the authors then calculated the effect at the occlusal surfaces of these ranges and means, comparing individual settings with mean settings. The results will dismay many who insist on the use of facebows and individual settings, for the individual settings held no advantages over the mean settings with the greatest error being no more than 0.3 mm! Their conclusion was that "The use of a facebow to register individual condylar angle and spatial relations yields no profitable reduction of occlusal errors compared to mean value setting". A more recent review came to the same conclusion: "the face bow transfer treatment procedure is not absolutely necessary to mount dental models on an articulator" and "there was no condylar axis of rotation during functional activity". [5]

It appears that in Scandinavia, this has been recognised for several decades, where the predominant use of semi-adjustable articulators has been by setting the casts in the geometric centre of the articulator, and by setting the condylar guidance angles to average values. [6,7] So it seems that the use of the facebow may not confer any great advantages and therefore by implication the use of any more complicated devices such as the pantograph and so-called 'fully adjustable' articulators will still require one to finally adjust occlusions once placed in the mouth. This has certainly been my experience, having used all these instruments clinically. The best articulator is still the patient, but this does not mean we abandon everything else, and so Part 7, the last in this series, will offer guidelines based on the evidence that has been summarised here.

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