Recording condylar movement with two facebow systems

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The facebow apparatus introduced by Snow in 1907 remains the basic template for facebows used today.[1] Although many modifications and improvements have been introduced during the last 90 years,[2,3] the facebow remains the best instrument available to orient the maxillary teeth to the centric relation position of the condyles and then transfer this orientation to the articulator. Once the maxillary cast has been correctly orientated to the condyles on the articulator, the mandibular cast can be related to the maxillary cast with a centric relation bite registration.

The facebow, since its inception, has been regarded as a necessary tool in dentistry for comprehensive treatment planning and diagnosis.[4-7] Some researchers have questioned the facebow's usefulness and contribution to functional occlusion in prosthodontics.[8-12] The precision of the facebow has been questioned because the maxillary cast is mounted in relation to arbitrary measurements and anatomic landmarks that differ between individuals. The focus of the debate appears to be the facebow's ability to exactly locate the true hinge axis or kinematic axis. Despite the debate, however, the majority of dentists who fully restore the mouth rely heavily on the facebow.[2,4,6,13-15]

Early gnathologists, such as McCollum and Stuart, seeking the true hinge or kinematic axis, modified the facebow and developed both instrumentation and techniques to better simulate true hinge axis location and movement.[16,17] Over the years, facebow modifications have included the use of various posterior reference points for facebow transfer techniques. These have in-

Abstract

Two different articulator systems are commonly used by orthodontists to reveal the maxillomandibular relationship for improved diagnosis and treatment planning. The purposes of the study were: (1) to compare the SAM and the Panadent articulator systems when recording condylar discrepancies for the same patient; (2) to evaluate the interchangeability of the SAM estimated facebow when mounting to the Panadent articulator; and (3) to evaluate the direction of condylar movement between centric relation (CR) and centric occlusion (CO). Maxillary and mandibular impressions, CO and CR bite registrations, and SAM and Panadent facebow recordings were taken for 37 patients. There were no statistically significant differences between the SAM and the Panadent systems ($p > 0.05$). However, the SAM facebow should not be used when mounting to the Panadent articulator. In most cases, the condyle moves down and back when the subject bites into maximum intercuspation.

Key Words

Articulator • Condylar displacement • Centric Relation • Facebow

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cluded the arbitrary surface markings which estimate the true hinge axis location,[18] arbitrary location of the hinge axis using the external auditory meati,[2] and techniques to precisely locate the true or kinematic hinge axis. As expected, the use of true or kinematic axis has been proven to be more accurate than the use of an estimated axis.[19] However, certain procedures in dentistry do not require the precision of locating the true or kinematic axis. Depending upon the degree of precision required, the arbitrary facebow in use today is a fairly accurate tool for mounting casts on a semiadjustable articulator.[19,20]

A growing trend in orthodontics is an increasing awareness and interest in functional occlusion.[4,21] As a result, more orthodontists have incorporated the use of diagnostic casts mounted on articulators in centric relation into their practices. Centric relation is a position that is anatomically determined and therefore repeatable.[22-24] Roth,[4] Dawson,[25] Williamson,[23] and Okeson[26] all agree that centric relation is defined as a position in which the condyles are seated against the articulator disc in their most superior-anterior position against the posterior-superior slope of the articular eminences and centered transversely.

The position of the condyles in centric occlusion has proven to be different than the position in centric relation in almost all individuals.[20,27,28] When the teeth bite into maximum intercuspation or centric occlusion, the condyles will move from the reference position of centric relation in three dimensions: horizontally, vertically, and transversely. The movement of the condyles from centric relation (CR) to centric occlusion (CO) is either in an inferior-anterior, straight inferior, or most commonly in a posterior-inferior direction.[27] These directional changes of the condyles from CR to CO always result in an anterior movement of the mandibular dentition, yet most often the condyles are moving distally. In CR, the overjet is increased and the overbite decreased in reference to CO.[24,27] This often significant dental change can affect the way a case will be diagnosed and can possibly alter the treatment necessary for correction of the malocclusion.

The recent interest by orthodontists in functional occlusion has led to the use of two different articulator systems (SAM, Great Lakes Orthodontics, Ltd, Tonawanda, NY, and Panadent, Panadent Corp, Grand Terrace, Calif). An accessory device allows the recording of condylar movement from CR to CO.[20,27] In addition to the added diagnostic value of mounted casts, the recording of condylar movement from CR to CO provides information necessary to convert a lateral headfilm taken in centric occlusion into a centric relation cephalogram.[24,28]

Wood and Korne, looking at the SAM system, have shown that for a screening mounting, diagnostic casts mounted in CR using a true hinge axis facebow yielded essentially the same condylar discrepancies as casts mounted with an estimated hinge axis facebow. They concluded that for initial diagnostic records, the estimated hinge axis facebow was fairly accurate for positioning the maxillary cast in relation to the true hinge or kinematic axis for the SAM articulator system.[20]

To date, no one has reported whether the SAM and Panadent articulator systems would record the same condylar discrepancy for the same patient. Furthermore, when both are mounted on the Panadent articulator, would the SAM estimated facebow position the maxillary cast identically to the Panadent estimated facebow?

This study had three purposes: first, to compare the SAM and Panadent articulator systems for recording condylar discrepancy on the same patient; second, to assess the interchangeability of the SAM estimated facebow; and third, to evaluate the direction of condylar movement between CR and CO and compare it with previous findings.

Materials and methods

Thirty-seven dental students volunteered for this study. Records obtained consisted of one set of maxillary and mandibular impressions, a centric occlusion (CO) bite registration, a centric relation (CR) bite registration, and two different facebow recordings.

To obtain the necessary data for analysis, the casts, bite registrations, and facebow recordings for each individual were handled in the following manner. First, the patient's maxillary cast was mounted to the SAM 2 articulator using the SAM facebow recording (system A). Using the CR bite, the lower cast was mounted to the upper cast. Condylar movement was then recorded from CR to CO using the Mandibular Position Indicator (MPI, Great Lakes Orthodontics, Ltd, Tonawanda, NY) with the CO bite placed between the casts. The same casts were then separated from the first mounting. Using the same SAM facebow recording, the maxillary cast was mounted to the Panadent articulator (system B). The pins that extend from the Panadent fossa boxes fit into the holes in the SAM facebow earrods if the dynalinks apparatus are removed. Using the same CR bite, the lower cast was again mounted to the upper cast. Condylar movement was recorded from CR to CO using the Condylar Position Indicator (CPI, Panadent Corporation, Grand Terrace, Calif) with the same CO bite placed between the casts. Finally, the same casts were separated from the second mounting. Using the Panadent facebow recording, the maxillary cast was mounted to the Panadent articulator (system C). Using the same CR bite, the lower cast was again mounted to the upper cast. Condylar movement was recorded as before using the CPI.

Maxillary and mandibular casts were obtained in the following manner. One set of maxillary and mandibular impressions was taken for each subject using an irreversible hydrocolloid material (Jeltrate Plus, Dentsply International Inc, Milord, Del) in nonperforated rimlock trays. The impressions were carefully placed in zip-lock plastic bags and poured within 15 minutes using type IV high strength dental stone (Vel-Mix, Kerr Manufacturing Co, Romulus, Mich). Poured impressions were separated after initial set. Casts were then closely inspected for detail and any unwanted artifacts were removed. The casts were trimmed and bases notched for ease of mounting.

The centric occlusion (CO) bite registration was taken with one thickness of pink dental wax (10X Wax, Moyco Industries Inc, Philadelphia, Penn). The wax was cut with scissors to cover the maxillary occlusal table extending from incisors to molars and laterally to buccal cusp tips. Care was taken to trim the wax so as to minimize horizontal overlap and possible distortion by the cheeks. Participants were instructed to bite completely through the warm (135°F) water-softened wax into maximum intercuspation position. The purpose of the CO bite was to prevent rocking of the casts during recording by the MPI or CPI. The wax was cooled with air before removal. During removal, the patient was instructed to avoid contact of the wax with their tongue and lips to avoid distortion from the mouth.

The centric relation (CR) bite registration was then taken by the method described in Appendix I. This method, the Roth power-bite technique, avoids tooth contact and allows the patient's own mandibular elevator muscles to seat the condyles in a reproducible neuromuscular position. The two-piece centric relation power-bite registration was carefully trimmed with a sharp scalpel blade to ensure only cusp-tip and incisal-edge indexing for mounting.

Both the SAM and Panadent estimated facebows were used to relate the patient's maxillary cast to his or her estimated hinge axis. The first two reference points used were the external auditory canals. Both the SAM and Panadent facebows are oriented on a line nearly parallel to the Frankfort horizontal plane when using soft tissue nasion to establish the height of the facebow in the front, thereby establishing the anterior third reference height. Three brown compound material adhesive bite-tabs were used on each of the metal bite-forks of both the SAM and Panadent facebows. These bite tabs registered one anterior incisal and two posterior cusp-tip indexed areas. The compound was carefully trimmed with a sharp scalpel blade to ensure only cusp-tip and incisal edge indexing prior to mounting the maxillary cast.

Manufacturer's recommendations for all clinical and laboratory procedures were followed. To eliminate instrumentation error, the same SAM-2 articulator and the same Panadent articulator were used for the study. All casts were mounted and remounted using fast set dental stone (Snow White Plaster #2, Kerr Manufacturing Co, Romulus, Mich).

For each of the subject's three mountings, differences between centric occlusion and centric relation at the articulator condyles were measured using a mandibular position indicator (MPI) when mounting to the SAM-2 and a condylar position indicator (CPI) when mounting to the Panadent. Each device can measure the three-dimensional changes of the articulator condyles between centric relation and centric occlusion. The horizontal and vertical changes in the sagittal plane at each articulator condyle correspond to the x and z changes, respectively, on the adhesive grid paper affixed to the sliding blocks of both the MPI and CPI devices. Transverse changes representing both condyles moving in tandem correspond to the y change shown by the dial gauge affixed to the top of the MPI and on the adhesive grid paper affixed to the sliding center platform of the CPI. Following manufacturer's recommendations, the casts were placed into the CO bite and held firmly to ensure plaster-to-plaster contact. The CO position of left and right articulator condyles were then marked with articulating paper (Accufilm I, Parkell, Farmingdale, NY). The right and left x and z values of CO position were recorded and the numbers were averaged to give Δx and Δz for each MPI and CPI recorded. All measurements of x, z, and y were recorded in multiples of 0.1 mm. All grid papers were read on a cephalometric tracing light box using a monocular lens fitted with a magnified grid calibrated to 0.1 mm.

Table 1
Mean condylar movement from CR to CO (mm)

System	Δx (horizontal)	Δz (vertical)	Δ y (transverse)
A - SAM facebow mounted to SAM articulator			
	-0.24 (±0.59)	+1.21 (±0.53)	+0.01 (±0.21)
B - SAM facebow mounted to Panadent articulator			
	-0.10 (±0.55)	+1.17 (±0.47)	+0.02 (±0.27)
C - Panadent facebow mounted to Panadent articulator			
	-0.25 (±0.58)	+1.20 (±0.53)	+0.06 (±0.30)

Δx: a '+' value means the CO position of the condyles is anterior to the CR position and a '-' value means the CO position of the condyles is posterior to the CR position

Δz:a '+' value means the CO position of the condyles is inferior to the CR position and a '-' value means the CO position of the condyles is superior to the CR position

Δy:a '+' value means the CO position of the condyles is to the subject's right of the CR position and a '-' value means the CO position of the condyles is to the subject's left of the CR position

All measurements were checked by a second operator.

Statistical analysis

Overall differences of the means between systems A, B, and C were compared. To assess the statistical significance of observed differences, paired Student *t*-tests were performed to detect the source of any differences in each direction of condylar movement when comparing different systems. For all of the statistical analyses, P 0.05 was used as the test criteria for statistical significance.

Results

Accuracy of the SAM and Panadent articulator systems

The mean condylar movements from CR to CO are listed in Table 1. To determine if a difference existed within components of the MPI and CPI, i.e., Δx, Δz, and Δy, a paired *t*-test was used to compare the systems. Table 2 outlines the paired *t*-test results showing that the average of the differences of Δx, Δz, and Δy between system A (SAM facebow mounted to the SAM articulator) and system C (Panadent facebow mounted to the Panadent articulator) were not significant. Therefore, there was no statistically significant difference when comparing the SAM and Panadent articulator systems' abilities to record the condylar discrepancy for the same subject, $P = 0.875$ for Δx, $P = 0.8504$ for Δz and $P = 0.0984$ for Δy. These values were nonsignificant at the $P > 0.05$ level.

Interchangeability of the SAM facebow

Table 2 outlines the paired *t*-test results showing that there was a statistically significant difference when comparing systems A and B and B and C in the x or horizontal direction. The differences were significant at $P < 0.001$. The results indicate that the SAM facebow is not accurate in the x or horizontal plane when used to mount the upper cast on the Panadent articulator.

Direction of condylar movement from CR to CO

The direction of condylar movement from CR to CO had an inferior component in 100% of the 37 subjects examined for all three systems. The comparison of condylar movement between systems is listed in Table 3. Condylar displacements for system A were 62.2% of the sample in an inferior-posterior direction, 5.4% straight-inferior, and 32.4% inferior-anterior. Condylar displacements for system C were 62.2% inferior-posterior, 0% straight-inferior, and 37.8% inferior-anterior.

Discussion

Accuracy of the SAM and Panadent articulator systems

The first part of the study was undertaken to determine the accuracy of two popular articulator systems. Orthodontists have increasingly relied on articulators to provide information about their patients' malocclusions when examined from centric relation (CR).[22,24,27] Centric relation position reveals the true anteroposterior, vertical, and transverse skeletal relationships, which are often masked by neuromuscular mechanisms that posture the mandible to avoid occlusal interferences that are not seen in the clinical exam.[4] Use of a CR bite registration that promotes condylar seating and avoids the neuromuscular feedback will uncover the true discrepancy.[29-31]

Positioning the condyle in the centric relation position often creates a "molar fulcrum" as the mandible rotates closed. When a discrepancy is present between centric relation (CR) and centric occlusion (CO) the first teeth to come into contact as the mandible closes from the centric relation position are usually the most posterior teeth.[27] The body of the mandible and teeth move forward from the initial occlusal contact in CR to CO. The condyle, however, will move inferior-posteriorly, straight-inferiorly, or inferior-anteriorly when rotating around the molar fulcrum into CO. When there is a CR-CO discrepancy, overjet increases and the overbite decreases.[27] Seating the condyle will move the mandibular body and dentition distally and will often result in a change from an Angle Class I molar relationship to a Class II relationship. If the patient has a large CR-CO discrepancy and the orthodontist is unaware of this situation, it is very likely the proposed treatment plan will change when the patient is rediagnosed from CR.[22,27,28,32] These treatment plan changes often include extractions, orthognathic surgery and/or complex restorative dentistry. Therefore, if one goal of treatment is to minimize CR-CO discrepancies, cases that are not mounted in centric relation may be misdiagnosed. Choosing an accurate articulator from which to make a diagnosis from CR is critical.

No significant differences were found when individual condylar movements recorded with the SAM and Panadent articulator systems, i.e., Δx, Δz, and Δy, were compared. It appears that the recordings and measurements of condylar movement made by the two systems will be similar. The comparison of condylar movement for the same patient, although not significantly different, did not result in identical condylar movements. The smallest and largest differences observed when comparing system A to system C ranged from 0.0 mm to 0.8 mm in the horizontal direction (Δx), 0.0 mm to 0.6 mm in the vertical direction (Δz), and 0.0 mm to 0.5 mm in the transverse direction (Δy). Most differences, however, were extremely small and were not equally distributed along the range.

The CR-CO discrepancies as determined by the MPI or CPI are used to monitor stabilization on a CR splint and to convert the lateral cephalometric radiograph, which is taken in CO, to a CR headfilm. Cephalometric measures of mandibular position have been shown to be significantly different when comparing a lateral headfilm taken in CO with a CR headfilm of a patient with horizontal and/or vertical condylar discrepancies greater than 2.0 mm.[28] The use of mounted diagnostic casts in centric relation and the use of a converted lateral cephalometric radiograph, when appropriate, provides the clinician with additional diagnostic information that may help in the formulation of a treatment plan that allows the patient to be treated to centric relation.[22,24,32] Also, the documentation of initial condylar position is extremely useful in today's litigious climate.[33] The SAM and Panadent systems have been shown to be equally effective and efficient at accomplishing these tasks.

Interchangeability of the SAM facebow

Since 1976 the SAM articulator system has been used by orthodontists in North America because of its ease of use. The SAM, along with the MPI, is useful in recording condylar movements between centric relation (CR) and centric occlusion (CO). The Panadent articulator became commercially available in 1974. However, the CPI was not commercially available until 1988. The Panadent system has two key advantages over the SAM: In the Panadent system, the relationship of the upper member to the lower does not change with normal use, and the Panadent better simulates mandibular movement. Orthodontists currently using the SAM system but who wish to switch over to the Panadent would appreciate interchangeable facebows. From a practice management point of view, the orthodontist requires many facebows but can get by with fewer articulators.

Table 2
Articulator system comparisons for each component of condylar discrepancy

	System comparison	P - value
Δx	A vs B	0.0006*
	A vs C	0.8750
	B vs C	0.0006*
Δz	A vs B	0.2731
	A vs C	0.8504
	B vs C	0.2425
Δy	A vs B	0.5345
	A vs C	0.0984
	B vs C	0.2482

* Statistically significant: $P < 0.001$

Δx: Average horizontal discrepancy left and right condyle
Δz: Average vertical discrepancy left and right condyle
Δy: Transverse discrepancy of left and right condyles in tandem

A: SAM Facebow mounting to the SAM articulator
B: SAM Facebow mounting to the Panadent articulator
C: Panadent Facebow mounting to the Panadent articulator

Interchangeability of the SAM facebow tests the adaptability of the two systems. The paired Student's *t*-tests showed a statistically highly significant difference, at the $P = 0.0006$ level, for the Δx horizontal movement of the condyle (Table 2). As a result, the SAM facebow should not be used with the Panadent articulator to record condylar discrepancy. Orthodontists wishing to switch from the SAM system to the Panadent system are advised to purchase Panadent facebows.

The differences in recording condylar discrepancies are likely accounted for by differences encountered when using a combination of the two systems (system B). The hole in each of the plastic ear rod pieces of the two facebows that fits inside the external auditory meatus corresponds with the estimated hinge axis. Upon visual inspection of placing the facebows in the external

Table 3
Direction of condylar movement between CR and CO

System	Inferior-posterior (down and back)	Straight-inferior (down)	Inferior-anterior (down and forward)
A - SAM facebow mounted to SAM articulator			
	62.2%	5.4%	32.4%
	(23 or 37)	(2 of 37)	(12 of 37)
B - SAM facebow mounted to Panadent articulator			
	51.4%	0.00%	48.6%
	(19 of 37)	(0 of 37)	(18 of 37)
C - Panadent facebow mounted to Panadent articulator			
	62.2%	0.00%	37.8%
	(23 of 37)	(0 of 37)	(14 of 37)

auditory meatus on a skull, it appears the hole in the ear rod piece is more distal on the SAM facebow than on the Panadent. For the SAM facebow, the ear rod hole fits on a plastic pin that extends laterally from the fossa boxes. For the Panadent facebow, the ear rod hole fits on a metal pin that extends laterally from the fossa boxes. The respective plastic and metal pins relate the posterior reference points on the facebow to the axis of each articulator. The difference between the SAM facebow to the Panadent probably has to do with the correction factor built into the SAM facebow based on the study by Teteruck and Lundeen.[2] The hole in the ear insert is located more forward on the SAM facebow than on the Panadent. Also, the distance between the upper and lower members of the articulator is greater on the SAM articulator than on the Panadent. These two differences likely account for the lack of interchangeability of the two facebows.

Direction of condylar movement from CR to CO

Following the studies of the mobility of the human mandible by Posselt,[34] there have been many further studies that describe the movement of the condyle from centric relation position to centric occlusion or maximum intercuspation position.[20,27,28,35] Condylar movement found in this study was compared with previous findings. The Roth power centric bite registration (Appendix I) uses an anterior stop to capture centric relation and allows the elevator muscles of the mandible to determine the most orthopedically stable joint position without occlusal interferences. Muscle and/or joint dysfunction will tend to prohibit the complete seating of the condyles.[22] A mandibular repositioning splint is often needed to eliminate muscle splinting and improve joint health, thereby allowing the elevator muscles to seat the condyles completely.[21,22,36]

The direction of condylar movement from CR to CO was inferior in 100% of the subjects examined. Also, the majority of condylar movements from CR to CO observed in this study (Table 3) was posterior and inferior, in agreement with the movements observed by Wood and Korne.[20]

In a later study, Wood and Elliott found the majority (63%) of condylar movements from CR to CO to be posterior and inferior.[27] Shildkraut, Wood, and Hunter also found the majority (75%) of condylar movements from CR to CO to be posterior and inferior.[28]

The exact direction of inferior movement of the condyles from CR to CO (Table 3), i.e., posterior-inferior, straight-inferior, or anterior-inferior, may be influenced by a number of factors. First, the direction of pull of elevator muscles across the TMJ can influence the direction of movement.[26] Second, according to Roth, the anatomy of the mandible combined with a "molar fulcrum" or posterior occlusal prematurity in CR when closing into CO can affect the direction of condylar movement.[22] As the mandible is closed over the initial contact, the condyles are subluxated with an inferior component. Finally, the use of an anterior stop with a forced distal guidance of the mandible when registering the centric relation bite may direct the condyles in a posterior direction. In addition, unless a patient is "deprogrammed" from his or her occlusion, or if a CR bite technique is used that does not allow capturing of the most superior/anterior condylar position, different CR-CO condylar discrepancies will result.

According to Slavicek, a 1.0 mm discrepancy at the condyle can result in a distal movement of the mandible equal to nearly half a premolar width in the dentition.[32] A posterior movement of the mandible of this magnitude can also result in lateral and anterior openbite situations that the clinician would not see if the diagnostic casts were not mounted in centric relation. The findings of this and other studies indicate that, in order to accurately diagnose a patient's occlusion (horizontally, vertically, and transversely), casts must be mounted in centric relation. Handheld models do not accurately disclose occlusal relations with the condyles seated in centric relation. Although some authors have disputed the usefulness of centric relation because of a feeling that it changes over time,[13] the majority of dentists who fully restore the mouth rely quite heavily on articulators. If the goal is to treat to centric relation, then orthodontists will need to diagnose the problem and plan treatment from the centric relation (CR) position. The use of an articulator system such as the SAM or Panadent to capture a centric relation position mounting is essential to uncover the true spatial relationship of the mandible.

Conclusions

1. The SAM and Panadent articulator systems record essentially the same condylar displacements from CR to CO.
2. The SAM facebow should not be used with the Panadent articulator.
3. In the majority of the subjects, the condyle moves down and back when the subject bites into maximum intercuspation.

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Appendix 1: The Roth Power Centric Relation Bite Registration

This bite registration is taken on the asymptomatic patient and/or the unresolved temporomandibular dysfunction patient as the best centric relation obtainable at that time. Because the patient may be unresolved and/or not deprogrammed from his or her occlusion, the power centric relation record is taken with anterior resistance. This resistance generates muscular activity of the mandibular elevator muscles, thereby aiding in seating of the condyles.

The wax bite is taken with Delar Bite Registration Wax (Bite Registration Wax, Delar Corp, Lake Oswego, Ore) and is made in two sections. The anterior section is made by folding the softened wax over to form four layers (more if anterior open bite). The anteroposterior dimension is dictated by the overjet and the width should include both the upper and lower anterior teeth. The posterior section is two layers thick. The anteroposterior dimension is trimmed wide enough to include the first molar and second premolar teeth, and does not extend too far buccally to be distorted by the cheek nor too far anteriorly to interfere with the anterior piece.

Procedure

1. The patient should be positioned at a 45° angle to the floor and instructed to relax.

2. The anterior section of wax is softened in a water bath at 135° Fahrenheit, then placed and held against the maxillary anterior teeth with one hand. Prior to actually taking the bite a cotton roll is placed between the upper and lower anterior teeth for 2 minutes in order to modify the neuromuscular engram. The tooth periodontal proprioceptors have been limited or removed as possible dictators of occlusal relation in centric relation.[29-31] The mandible is guided into centric relation by supporting the condyles upward near gonion on the lower border of the mandible with the middle and index fingers. Simultaneously the thumb of the same hand pushes downward at pogonion. This aids the patient in seating the condyles in an anterosuperior position. The anterior section of wax is soft, though stiff enough to offer resistance to the closing muscles of the mandible. The patient is instructed to close slowly into the wax until approximately 2.0 mm of posterior clearance exists at the point of first contact. The patient is instructed to hold the position and the wax is allowed to harden.

3. The anterior section of wax is removed when it has hardened to the point where it can be removed without distortion. The wax is chilled in ice water and trimmed to allow passive indexing of the mandible into the centric relation position. The cotton roll is replaced when the wax is removed to allow no tooth contact.

4. The posterior section is heated in the water bath until it is "dead soft." The posterior section is then placed on the upper teeth and supported with your fingers on the buccal surfaces. While holding the posterior section in place, the chilled anterior section is placed on the upper teeth. This can be supported with the same hand that is holding the posterior section.

5. The mandible is guided into centric relation as above with the other hand. The lower anterior teeth should fit into the hardened anterior section of wax without any anterior slide into the index. As the patient closes into the hardened anterior section, the patient is instructed to "close as firmly as possible and hold it." The condyles will then be seated. The wax sections are both removed when the posterior section has hardened sufficiently to avoid distortion.

6. The two-piece wax record is trimmed with a sharp scalpel blade to ensure only cusp tip indexing when mounting the casts.