Obtaining accurate centric relation records for the purpose of mounting diagnostic casts is thought by the authors to be essential for correct diagnosis and treatment planning. For this study two basic questions were asked: (1) What is the best technique to obtain an accurate centric relation recording for diagnostic mountings in the presence of malocclusion? and (2) Is there enough variance between recording techniques to make a difference at the tooth level and affect the treatment plan? This research demonstrates the large variability in centric relation recordings obtained by six operators using the same technique, and between various techniques at repeated intervals over an extended period of time, all on patients with malocclusion. The use of cotton rolls for initial joint compression and retrusion followed by recording with the leaf gauge appears to be the best method for obtaining efficiency, accuracy, and patient comfort. The difference at the tooth level resulting from different techniques is, in the authors’ opinion, significant.

Semantics

Semantics used to discuss condyle/disc assembly position and/or movement within the glenoid fossa is important for clear, thoroughly understood, meaningful discussion. Terminology used in this paper is described in the following paragraphs. Common terms for condylar position and movements are superior and inferior and anterior and posterior, which relate to vertical and horizontal planes, respectively (Fig 1). Confusion is caused by the visual orientation of the condyle/fossa and by using terms not specific enough to describe the dynamic movements occurring in the nonvertical, nonhorizontal plane system of the temporomandibular joint. The condylar movements within the fossa are related to the angle of the eminentia, which varies from patient to patient. The terms retrusion, protrusion, compression, and distraction more accurately describe condylar movements within the fossa, regardless of the angle of the eminentia (Fig 2). These terms elicit a better understanding of condylar movements and avoid situations in which the previous terminology may describe more than one movement simultaneously. For instance, superior could describe both retrusion and compression. Use of the terms retrusion, protrusion, compression, and distraction avoids potential confusion and allows visualization and understanding of the component parts of condylar movement without reference to the misleading horizontal and vertical planes. The authors believe this is essential to understanding cause and effect of condylar movement.

For example, the statement is often heard that the leaf gauge “tends to distalize the condyle.” One cannot know what that statement really means in terms of precise condylar movement (Fig 3). Using the semantics of this paper, a simple definition of centric relation would be “the absence of protrusion and the absence of distraction in both condyle/disc assemblies simultaneously.” By this definition, the method of determining centric relation by recording the most retruded and most compressed condylar position is the preferred technique.
Materials and Method

A transverse horizontal axis location was obtained on five subjects using the Stuart facebow. The maxillary casts were mounted to a Denar Mark II articulator (Denar, Anaheim, CA) using Whip Mix mounting stone (Whip Mix, Louisville, KY). For Dawson’s technique of bimanual manipulation, Delar Bite Registration wax wafers were used. Leaf gauge records and bimanual manipulation without patient assistance records were taken with Moyco extra hard pink beauty wax (Moyco Union Broach, York, PA). Impressions were obtained using irreversible hydrocolloid and casts were poured with Die Keen (Modern Materials, Miles, South Bend, IN) stone. The casts were inspected under high magnification to remove air-entrapment imperfections.

Data were recorded with 1-mm graph paper on the Denar Veri-check. The indicator rod for the Veri-check was machined to a sharp point. The same operator marked all recordings to avoid multiple operator variability. Designs for Vision 4.5 x binoculars (Designs for Vision, Ronkonkoma, NY) were used to observe the indicator rod position. The observed position was transferred to 40-mm-square graph paper to enhance visibility. Different colored adhesive dots were assigned to the different methods used and applied to the enlarged graph paper. The centric relation recordings were obtained in five sessions, one month apart. No restorative dental treatment was performed on any subject during this time. Maximum intercuspal position was marked on the graph paper to provide a baseline position against which the other recordings could be referenced. Each month all members of the study group made recordings on each other using the various techniques.

Recording Techniques

In the following descriptions, the term condyle rather than the more correct condyle/disc assembly will be used for brevity. The following techniques were tested.

1. Bimanual manipulation without patient assistance. The patient was asked to relax and “give the jaw” to
the operator who, with finger and thumb counterforces, torqued the mandible and thus the condyles into a "seated" compressed and retruded position. After practicing with the patient to assure cooperation, Moyco extra hard beauty wax wafers, softened in a 142°F water bath, were bilaterally placed on the posterior maxillary teeth, and the mandibular teeth were squeezed into the wax by the operator following the above described procedure. This was a recording of an operator obtained position.

2. Bimanual manipulation as described by Dawson. Using Delar Bite Registration wax wafers, the edges (but not the center) were repeatedly flamed until shiny and soft. After lightly seating the wafer against the maxillary teeth, the operator bimanually manipulated the mandible with finger and thumb counterforces to a compressed and retruded position. While loading the joints with this pressure, the patient was asked to verify that no tension or tenderness was felt in either joint and then was asked to squeeze the teeth into the wax while the operator held the mandibular posture. The wafer was removed and trimmed to the middle of the lower buccal cusp indents. The wafer was returned to the mouth, and the process was repeated. The patient was asked to tap the teeth into the wax and then to touch lightly. The operator inquired which side touched first. The process was repeated until the patient could not detect a contact on one side before the other. The wafer was removed and chilled in ice water. The entire process was repeated again and the recording was accepted when the patient could not detect a contact on one side before the other.

3. Leaf gauge for 10 minutes. The leaf gauge was placed between the maxillary and mandibular central incisors, and the patient asked to "close, slide the lower jaw slightly forward, then all the way back," then "squeeze with moderate pressure." The pressure was alternated with relaxation using Rocabado's technique of 6 seconds of closure force, 6 seconds of relaxation, for the entire 10 minutes. The centric relation position was captured using Moyco wax wafers placed on the maxillary posterior quadrants. The patient closed into the wax to contact the leaf gauge, moved slightly forward, then all the way back and held the position with pressure until the wax cooled to body temperature. Enough leaves were used on all subjects to assure that no posterior contact would occur during the test period. The same number of leaves was used throughout the 5-month period by all operators on each patient to reduce the potential for axis of rotation error.

4. Leaf gauge after "terminal compression." After the above technique was completed, leaves were removed until the first occlusal contact was felt. Two leaves were added, and the patient was instructed to slide slightly forward, then all the way back and to hold continuously with moderate pressure until an occlusal contact recurred. Two leaves were added, and the process was repeated until no contact occurred for a time span of 15 minutes. Centric relation was recorded as above.

5. Cotton rolls for 2 minutes. One cotton roll was placed bilaterally between the premolars. The same instructions as for the 10-minute leaf gauge technique were used, with one important difference. The patient was asked to bite as hard as possible without incurring pain. This was followed by a leaf gauge recording.

6. Cotton rolls for 3 additional minutes (total of 5 minutes). The same instructions as for the 2-minute procedure were used. This was followed by a leaf gauge recording.

7. Cotton rolls for 5 additional minutes (total of 10 minutes). The same instructions as for the 2-minute procedure were used and then followed by a leaf gauge recording. Recordings from protocols 5, 6, and 7 tested the effect of time under heavy loading.

8. Immediately after protocol 7, the patient again was asked to bite on cotton rolls for 1 minute, followed by recording of a bimanual-manipulation operator-determined position as described in protocol 2. This was to test the difference between operator-determined bimanual positions before and after patient closure muscle recruitment.

9. Immediately after protocol 8, the patient again was asked to bite on cotton rolls for 1 minute, followed by leaf gauge recording. This was to test for any difference between the recording methods.

10. Immediately after protocol 9, the patient again was asked to bite on cotton rolls for 1 minute, followed by recording of a bimanual-manipulation operator-determined position. This again was to test for a difference between recording methods.
11. After protocol 10, the leaf gauge again was used as in protocol 4 to obtain the terminal leaf gauge position. This tested the effect of a repeated terminal compression after all the other techniques had been accomplished.

Results

This research illustrates that in the presence of malocclusion there is a wide variance in the amount of compressibility of the temporomandibular joint, and a significant variance in retrusion, depending on the recording technique used. Evaluation of the three most compressed and most retruded records of all five patients showed that 13 of 15 records were cotton roll compressed/deprogrammed and leaf gauge guided. The other two were terminal leaf gauge recordings (Table 1).

In general the non-leaf gauges–guided recordings (bimanual) were the least retruded and the least compressed. The range of all recordings was 1.5 mm in protrusion and 3.0 mm in distraction. Leaf gauge guided recordings had a range of 0.8 mm in protrusion and 2.0 mm in distraction. Leaf gauges–guided recordings with a minimum of 5 minutes of cotton roll deprogramming had the smallest ranges of protrusion (0.6 mm) and distraction (1.4 mm) (Table 2).

The subject had the least amount of occlusal wear and the least amount of discomfort (almost none) while biting on the leaf gauge displayed the best reproducibility of the recordings (Fig 4). This subject had no discomfort on the right side while biting on a leaf gauge. The Dawson bimanual recording and all but one of the cotton roll and/or leaf gauge recordings nested within 150 μ of maximum intercuspsion on this right side. Those who believe in a correlation between centric relation, maximum intercuspsion, and masticatory muscle harmony can take heart from this insufficient, incomplete, non-conclusive morsel of supposition.

Fatigue is an important factor in all methods used and most likely caused some of the variability seen. We initially expected the terminal leaf gauge recording (protocol 4) to be the best, but it was not. Given that this research group is composed of dentists who are motivated to endure pain to prove a point, the general patient population would be even less inclined to maintain maximum compression and retrusion with protocol 4.
Discussion

Initially, a earbow was used to mount the maxillary casts, and the centric relation recordings were confusing and illogical. The same recordings appeared logical after remounting with a located axis. Therefore, mounting the maxillary cast with an accurate transverse horizontal axis appears to be essential for this type of research.

Usually it is desirable to determine a preliminary treatment plan before joint resolution is initiated. The accuracy of the treatment plan is dependent on the accuracy of the mounted casts. It has been reported\(^1\) that with an unresolved temporomandibular joint, centric relation is very alterable, depending on the duration of pressure and amount of pressure applied to the joint during the recording procedure. McHorris\(^2\) has urged the profession to always resolve
the temporomandibular joints and musculature before reconstruction to avoid the necessity of re-mounts.

The premise of anterior guidance as a protective occlusal scheme for the posterior teeth and a safe and comfortable occlusal scheme for the anterior teeth involves the belief that the masseter, internal pterygoid, and temporalis muscles have reduced elevating activity in the absence of posterior periodontal ligament stimulation.\textsuperscript{3} This is exactly what occurs when the leaf gauge is used. Therefore, Wilson suggested that posterior tooth loading without tooth contact would yield (1) more efficient compression of the joint components and (2) equally effective deprogramming of the lateral pterygoids, prior to recording with the leaf gauge. Cotton rolls placed bilaterally anterior to the equilibrium point were the easy answer. They should be moved around on the premolars until the patient feels equal pressure on both sides while applying closure force. The patient should then slide the mandible slightly forward, then all the way back, and then bite hard.
The pleasant surprise of this technique is that the discomfort described by patients while biting on the leaf gauge is of much less intensity, or completely absent, when biting on cotton rolls. One subject in this study who, with repeated attempts over the years, has never been able to cycle the lateral pterygoid muscles, was able to cycle on the first attempt in 9.5 minutes while using cotton rolls. The leaf gauge remains the diagnostic tool for the observation of muscle pain and the guide for centric relation recording, but we think the use of cotton rolls is very helpful for muscle deprogramming and physical therapy, as well as for enhancement and efficiency of centric relation recording. It already has been helpful in our practices. We also find the use of cotton rolls as an adjunct to the leaf gauge during equilibration to be a very significant advantage.

No technique captured the exact same position month after month, even when done by the same operator on the same patient at the same vertical dimension. However, even though needle-point reproducibility was not achieved, it is interesting to observe the relative positions obtained by the various techniques, as seen on the Vericheck. When the various techniques were compared, the bimanual-manipulation techniques consistently were less compressed and less retruded. The reader should note that bimanual manipulation is a learned skill, and in Dr. Dawson's hands, the above statement might not be true. When the leaf gauge was used alone, retrusion was achieved but compression was not. When cotton rolls were used to obtain "resolution for today," a more compressed (less distracted) and slightly less retruded position was generally recorded.

It is also interesting to observe the pattern of the leaf gauge-guided positions (both with and without cotton roll deprogramming). The pattern is a rather narrow band of retrusion-protrusion variability with a large compression-distraction variability (Fig 5). Discomfort and muscle fatigue appear to play a significant role during the recording process.

The second question asked was whether there is enough variation between mountings from different recording techniques to make a difference at the tooth level and would this affect the treatment plan? To address this question a second mandibular cast was mounted using the relation from protocol 7 to compare with the mounting from protocol 1. The difference was judged to be significant in both the amount and location of posterior occlusal adjustment, and the treatment required to obtain anterior disclusion. The authors suggest that a proper centric relation recording technique for unresolved joints requires closure-muscle recruitment for compression of the joints for a minimum of 5 minutes prior to recording with the leaf gauge. This technique may allow the diagnostician to gain insight into the future maxillomandibular relationship when malocclusion has been eliminated.

Based on the data observed, the leaf gauge recordings do not demonstrate a distalization of the condyles, if that term implies distraction. However, many of the recordings taken bimanually without patient closure-muscle recruitment were more distracted than the condylar position recorded at maximum intercuspation. We interpret this to indicate that it is very easy for wax, as a recording medium, to cause distraction by functioning as a fulcrum.

Conclusion

These research findings confirm that, in the presence of malocclusion, there is a wide variance in centric relation recordings, regardless of the operator or technique. Because of the large differences noted in some subjects, there could be sufficient difference at the tooth level to affect treatment planning. The recorded variance in compression/distraction was 3.0 mm and in retrusion/protrusion was 1.5 mm. Proper centric relation-recording technique gives the advantage of knowing, with reasonable accuracy, what the maxillomandibular relationship will be after resolution of the joints and musculature. This enhances more precise treatment planning. We strongly recommend muscle deprogramming and joint compression with closure-muscle recruitment by the use of cotton rolls for at least 5 minutes, followed by a leaf gauge-guided centric relation recording.
Appendix

The following codes and colors were assigned to the various methods used.
- Black—Maximum intercuspsation
- Red—Protocol 1 by mentor
- Orange—Protocol 1 by others
- Yellow—Protocol 2 by mentor
- Green 10—Leaf gauge at 10 minutes
- Green T—Terminal leaf gauge
- Blue C2—Cotton rolls for 2 minutes followed by leaf gauge
- Blue C5—Cotton rolls for 5 minutes followed by leaf gauge
- Blue C10—Cotton rolls for 10 minutes followed by leaf gauge
- Blue 11B—Cotton rolls for 11 minutes followed by protocol 1
- Blue 12L—Cotton rolls for 12 minutes followed by leaf gauge
- Blue 13B—Cotton rolls for 13 minutes followed by protocol 1
- Blue CTL—Cotton rolls for 13 minutes followed by terminal leaf gauge

References


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