A Cusp-fossa Equilibration Technique Using a Numbered Leaf Gauge*

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INTRODUCTION

Occlusal equilibration is one form of occlusal therapy. A less technique-sensitive equilibration procedure is presented in which a numbered leaf gauge is used to replace operator-guided manipulative procedures to register premature contacts in centric relation jaw closure. The leaf gauge is used as part of the cusp-fossa analysis technique which fulfills gnathological criteria.

The signs and symptoms of occlusal disease are generally classified as tooth symptoms, TMJ or muscle symptoms, or periodontal problems.¹

Persons suffering from the signs and symptoms of "occlusal disease" or "pathological occlusion" require some form of occlusal therapy in order to solve their problems. The various forms of occlusal therapy usually considered are: equilibration; restorative procedures, prosthetic or orthodontic; orthognathic surgery; or various combinations of these modalities.

The fastest, and usually the least expensive form of occlusal therapy is occlusal equilibration. It is the purpose of this paper to discuss occlusal equilibration as a treatment modality to alleviate the signs and symptoms of occlusal disease.

One must have a philosophy of occlusion prior to attempting any form of occlusal treatment. I believe the gnathological concept as advocated by McCollum and Stuart provides the kindest, most comfortable, and most stable occlusion.²

According to the gnathological concept, the prerequisites for occlusal equilibration (or any form of occlusal therapy) are:

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1. The posterior teeth must stop the jaw closure and neither guide nor deflect the closure. A cusp to fossa relationship provides the most ideal closure stops.

2. The anterior teeth must be coupled together to provide immediate disclusion of the posterior teeth in any eccentric jaw movement.

3. This disclusion must be in harmony with the dictates of the temporomandibular joints; one cannot arbitrarily alter the form of the canines or anteriors, disregarding joint function.

In my experience of treating patients with the signs and symptoms of occlusal disease it is only possible to equilibrate approximately 60% of them. The other 40% require other treatment modalities such as orthodontics, restorative, prosthetic, etc. The only way to determine which patients are among the 60% who are equilibratable is to mount casts accurately and perform a diagnostic equilibration prior to attempting intraoral procedures. This is especially true if you are teaching undergraduate dental students or graduate dentists who are just entering into the area of occlusal therapy.

For the same reason, in the 60% who are equilibratable it is important to develop a reliable technique which is equally effective and teachable to the inexperienced as well as the experienced operator. Probably the most difficult part of any equilibration technique is obtaining and marking the true centric relation prematurities in a step by step fashion as the equilibration proceeds.

I believe the leaf gauge accomplishes this prerequisite better than any of the jaw manipulative techniques or other mechanical devices.

A leaf gauge (Fig. 1) is a very simple device similar to a feeler gauge, except that all leaves are of the same thickness. Leaves may be made of mylar, polyester, polycarbonate, acetate, or other types of plastic material. Ideally they should bend freely but not crease and should rebound to their original shape for reuse.

Long introduced the leaf gauge in 1973 at which time he discussed its construction and use in locating and recording centric relation and in adjusting occlusion.\(^3\)

Williamson has done electromyographic research utilizing the leaf gauge relative to its clinical application in determining and recording centric relation and has confirmed its efficacy.\(^4\)

Golsen and Shaw have confirmed the use of the leaf gauge and its effectiveness in tripodizing the mandible for interocclusal record techniques and in occlusal adjustments.\(^5\)
Dr. Regenos and I have been teaching and advocating the use of the leaf gauge in our continuing education courses since the mid-seventies. Shankland and Ralston reported the use of the leaf gauge and our teaching philosophy in 1983.6

Rosenblum conceived the idea of numbering the leaves and has an article, co-authored with Huffman, describing a method of numbering the leaves.7 A commercially available (Huffman Leaf Gauge, Huffman Enterprises, Columbus, Ohio), polyester, numbered leaf gauge has merit not only for its convenience in observing and recording the number of leaves but in its superior effectiveness over thicker gauges. Its leaves are only 0.1 mm, which makes its discriminatory capabilities advantageous.

HOW TO TRIPODIZE THE MANDIBLE UTILIZING A LEAF GAUGE

The leaf gauge is held by the dentist or assistant with “X” number of leaves placed between the patient’s opposing incisors at the maxillary anterior midline parallel to the lingual plane of the central incisor teeth. The patient is instructed to close on the back teeth until a lower front tooth just touches the underside of the leaves. “X” number of leaves is the number comprising a stack thickness at which the patient can just barely feel a posterior tooth contact (arrived at by the trial and error additions of leaves). With X+1 leaves the patient initially cannot feel any posterior tooth contact. However, after holding the jaw closed with only
half-hard closing force for approximately 15—20 seconds, the patient usually will again be able to feel a posterior tooth prematurity. The patient advises the operator at the first sign of tooth contact and another leaf is added (Fig. 2).

This procedure is repeated with X+3, X+4, etc. leaves. The dentist keeps adding leaves in a similar fashion until the patient can close with a non-tiring half-hard force for three to five minutes without feeling any posterior tooth contact. At this time the mandible is said to be tripodized in its centric relation, with the right and left condyles seated in their respective glenoid fossa housings with one lower incisor tooth contacting the under side of the leaf gauge. This eliminates potential operator-guided error in manipulating the patient’s jaw into centric relation by permitting the patient’s own neuromusculature to seat the condyles correctly. This, according to McMillen, is the most satisfactory way to achieve correct condylar seating.

The average patient requires the addition of approximately seven (7) leaves to arrive at the tripodized position. Once you have observed this phenomenon it becomes obvious that if you were to adjust a patient’s occlusion by mere operator-guided jaw manipulative techniques, the condyles would not be seated in their uppermost positions and, no matter which equilibration technique you
use, you will end up with deflective malocclusion. The next time you perform an occlusal equilibration by whatever manipulative technique you normally employ, we suggest testing it with a leaf gauge when you have finished. You can very easily determine whether you have deflection remaining or not.

**HOW TO USE THE LEAF GAUGE FOR EQUILIBRATION**

When using the leaf gauge for occlusal equilibration, the finalized number of leaves is determined by that number wherein the patient cannot feel posterior tooth contact after biting on the leaves for three minutes. At that point remove one leaf, wipe off the first premature area with a dry 2 x 2 gauze sponge and position a strip of mylar articulating film held in a Miller forceps over the arch of teeth (Fig. 3).

Position the leaf gauge and instruct the patient to close on the back teeth and, as soon as a posterior tooth contact is felt, to tap up and down — thereby marking the first premature contact.

The operator then analyzes the marks, using the cusp-to-fossa criteria, and adjusts the prematurity. In addition to the marks on the teeth, the operator uses spray-painted diagnostic casts for reference along with a selective grinding list based on information derived during the diagnostic equilibration.

After the prematurity is adjusted, the patient closes again with the same number of leaves in place as before the adjustment to make sure enough tooth structure has been removed. This is done by testing for tooth contact with .0005” plastic “shim stock” (Shim Stock, Artus Corp., Englewood, N.J.).

If it holds the shim stock the tooth is re-marked with the mylar marking film (either Accufilm II [Parkell Products, Inc., Farmingdale, N.Y.] or MDS II Truespot [MDS Products, Inc., Anaheim, Cal.]) and readjusted. If the shim stock pulls free and no other tooth contacts, another leaf is removed and the next prematurity is marked, adjusted, and retested in a similar fashion. This procedure is repeated until all of the posterior teeth hold shim stock uniformly, there is no longer any deflection upon closure, and all of the marks have migrated to the cusp tips and fossa bases with no marks on inclined planes.

When these criteria have been satisfied, the equilibration is complete. As an additional test, 30 gauge Kerr’s green casting wax can be used for further verification of the accuracy of the equilibration. To do this, two strips of wax are cut and are placed over the upper right and left posterior teeth. The patient closes on these strips which, after removal, are examined for tooth perforations.
A satisfactory equilibration is indicated when either multiple perforations made by all the cusps (or no perforations) are seen in both strips. In the absence of these two circumstances, the existence of only one perforation in either strip indicates that the equilibration is not yet complete.

During the equilibration process, the patient's neuromuscular response is constantly being modified until, when the equilibration is complete, the dentist will have elicited a neuromuscular response which enables the patient to permit the dentist to forcefully and repeatedly close the mandible into centric relation closure without resistance.

Once centric relation closure has been established and perfected, the dentist is ready to check for eccentric disclusion. Our technique organizes the ridge and groove directions for eccentric as we do the centric adjustments; therefore, additional adjustments are rarely required in the eccentric excursions. However, both working and balancing movements are checked using an operator-guided lateral movement similar to that used when making a pantographic recording. Adjustments are made as necessary (following the recommended technique).

Occasionally, when canine disclusion cannot be established ideally as determined by the diagnostic equilibration, we may elect to build up the canines with acid etch composite to achieve disclusion. If this is the case we only equilibrate centric relation occlusion, add the acid etch composite to the canine (and/or anteriors), then check and adjust the eccentric relations as necessary.

Clark and Adler discussed the various current philosophies of occlusal equilibration. It shall not be the purpose of this paper to reiterate these concepts nor to argue their pros and cons.

There are many published definitions of occlusal equilibration. Each dental specialty offers its own unique definition. There seem to be as many definitions as there are authors. The periodontists make reference to the health and well being of the periodontium as part of their definitions. The members of the American Equilibration Society, whose interest lies in TMJ dysfunction, make reference to the health and stability of the temporomandibular joints and the normalization of function of the muscles of mastication by selective grinding of the teeth. The restorative dentists stress restoration of normal jaw function and stability of the occlusion as they define “occlusal equilibration.”

For purposes of this paper we shall use a more generalized definition: “Occlusal equilibration is the process of correcting stomatognathic dysfunction by recontouring tooth surfaces through selective grinding procedures.”
The actual technique is described in detail in our manual\textsuperscript{10} and will only be discussed briefly in this article. We use a modification of Guichet’s "enameling of cast" exercise incorporated into our teaching of occlusal equilibration (Fig. 4).\textsuperscript{11}

The marks represent three things:
1. Areas where articulating film marks would be located on opposing cusps if a particular type of prematurity were present.
2. Areas where facets of wear would be evident with such a prematurity.
3. Indications of the area to be analyzed for adjustment by selective grinding.

Quadrant 1 (Cast I) represents the marks which would be made by articulating film on opposing teeth if a working type of centric prematurity was present. It also depicts areas of potential working side eccentric interferences.

Quadrant 2 (Cast II) represents the marks which would be made by articulating film on opposing teeth if a balancing type of centric prematurity was present. It also depicts areas of potential balancing eccentric interferences.

Quadrant 3 (Cast II) represents opposing premature articulating film marks if a centric prematurity exists resulting in a straight P.A. deflective slide, with no lateral slide.

Quadrant 4 (Cast II) represents opposing marks in protrusive excursions.

We recommend diagnostic equilibration on accurately mounted casts before any intraoral procedures are performed. The patient should be free of pain and be neuromuscularly relaxed on bite-
plane therapy prior to mounting diagnostic casts.

Opposing arch marks will be analyzed on the basis of the marks on the various quadrants of the enameled of cast. If a patient has a lateral component to the centric hit and slide, the marks will correspond to those found on either Quadrant 1 or 2.

Any type of centric slide as well as any working or balancing eccentric interference involves marks on the distal inclines of the mandibular teeth and the mesial inclines of the maxillary teeth. Any type of working prematurity (Quadrant 1) either in centric or eccentric involves opposing marks on a centric cusp opposing a non-centric cusp, e.g. lower buccal cusp with upper buccal cusp or upper lingual cusp with lower lingual cusp.

All working types of prematurities involve marks on the outer inclines of the centric cusps and the inner inclines of the non-centric or shearing cusps. Since we always adjust the centric cusp, only one of the teeth would be adjusted in this instance.

Balancing types contact (Quadrant 2) in either centric or eccentric always involve contacts of a centric cusp against a centric cusp, e.g. mandibular buccal cusp vs. maxillary lingual cusp. Furthermore, these marks are always on the inner inclines of both cusps. Since we advocate adjusting centric cusps, both the mandibular and maxillary cusps must be adjusted in this situation. Dawson, in his text, recommends only adjusting one of the cusps in this situation and offers the operator the choice of either the mandibular or maxillary. We will elaborate later why this option is inadequate.

When adjusting an occlusion on diagnostic casts or in the patient's mouth, we use a mylar articulating film which marks on both sides so that we can see the mark on the mandibular and maxillary teeth which are in premature contact. These marks are analyzed on a cusp-to-fossa basis. The mark that appears on an inclined plane of the centric cusp (mandibular buccal or maxillary lingual) is analyzed to see what direction it would have to move to migrate to the tip of the anatomical cusp. When the opposing arch mark is analyzed, we find if its mark migrates in the same direction and magnitude it will place its mark over a fossa. We then adjust that pair of prematurities as described in the next section on how to adjust.

We follow the basic ideas presented by Glickman in his text; namely, that of grooving, spheroiding, and pointing (Fig. 5 a–f).
Fig. 5a. An unfacetet distobuccal cusp of a normally occluded mandibular first molar has its premature contact on the distobuccal surface of the cusp.

Fig. 5b. During tooth abrasion (approximate wear patterns are suggested by the shaded areas of the drawing), the premature contact migrates gingivally from its original position to a new position on the buccal facet.

Fig. 5c. Grooving and spheroiding are sculptural procedures. They allow the dentist simultaneously to “migrate” (reposition) the cusp tip and premature contact to more favorable occlusal positions — while eliminating sharp angles and flat surfaces created during the abrasion processes (dotted lines indicate original tooth contours — shading indicates areas to be removed during the grooving and spheroiding process). Vertical dotted lines indicate that the grooving and spheroiding leave the recontoured cusp tip in the same relative mesiodistal and buccolingual position as that occupied by the original cusp tip. Grooving and spheroiding combine to “point” the originally flattened cusp so it can assume a shape similar to that of the originally unabraded cusp and so it can pass through opposing groove escapeways.

Fig. 5d. Grooving is the first step prior to spheroiding. The bur is sunk into the developmental grooves mesial and distal to the contact targeted for migration. The bur is moved across the triangular ridge from one developmental groove to the other. The movement of the bur is controlled and directed so that it relocates the cusp tip mesially or distally while reshaping the contours of the cusp.
Huffman

Fig. 5e. Spheroiding starts with a back and forth mesiodistal movement of the bur in two curved planes. The first curved plane of contour lies between the central ridge of the buccal surface of the cusp and the distobuccal developmental groove (the central ridge lies along the greatest vertical convexity of the outer surface of a cusp and extends cervically from the cusp tip). The second curved plane of contour lies between the central ridge and the mesiobuccal developmental groove. As the bur moves across these planes, it eliminates the flat planes of wear and recreates the spherical contours of the original tooth form.

Fig. 5f. Pointing of the cusp is the end result of the combined grooving and spheroiding procedures. The cusp has been repositioned while surrounding surfaces have been reshaped, smoothed, and rounded.

We adjust centric relation first and adjust only the centric holding cusps. The reason for adjusting centric first is that we teach undergraduate dental students and dentists in our postgraduate occlusion courses to perform a diagnostic equilibration on mounted casts prior to intraoral selective grinding. This mounting is made on a semiadjustable articulator, preferably a Whip-Mix model 8300. It is financially impractical to pantograph a patient, mount casts on a fully adjustable articulator, and program the instrument merely for purposes of a diagnostic equilibration. Since only centric relation is accurate on a semiadjustable articulator we would be in error to adjust eccentricities first. By using the leaf gauge, the patient's own neuromusculature seats the condyles in their tripodized centric relation position, making the equilibration more accurate if centric is done first. The potential of operator-induced mandibular guidance error is eliminated. Also, by using this technique, eccentric interferences, the most difficult to record, are essentially eliminated.

The centric cusps are adjusted rather than the noncentric cusps because we desire to narrow the occlusal table during the occlusal equilibration. Examination of tooth morphology indicates that occlusal tables are narrowed by the inward curvature of the outer surfaces of the centric cusps, whose tips are "warped" towards
the center of the tooth. This permits the forces to be centered over the long axes of the teeth. Another reason for adjusting the centric cusps is that as we adjust centric relation we are also organizing eccentric ridge and groove direction for disclusion. This can best be accomplished by adjusting the centric cusps.

The first thing to do in each new step is to “groove” or enhance and accentuate the anatomical grooves on both the mesial and distal of each centric cusp as it is adjusted. Grooving permits us to migrate the premature articulating film mark mesially or distally from a cusp slope to the anatomical cusp tip. Grooving further permits the pointing of the cusp tip in the mesio-distal dimension. The operator must know and understand ridge and groove directions and anatomical tooth form in order to orient ridges and grooves correctly (Fig. 6).

The next step in the actual equilibration procedure is called “spheroiding”. Spheroiding is the recontouring of the outer inclines of the centric cusps, which permits the narrowing of the occlusal table in the bucco-lingual dimension. Ideally we would prefer to do this at all times; however, spheroiding can only be accomplished when we are dealing with a Quadrant 1, or working type of centric prematurities because this is the only time the marks are on the outer inclines of the centric cusps (Fig. 7).

Conversely, when adjusting balancing types of centric prematurities, since the marks are always on the inner inclines, we cannot “spheroid” or narrow the occlusal table. Rather, we must adjust the inner inclines so that the marks migrate to the tip of the cusp. This type of adjustment tends to widen the occlusal table which is, ideally, undesirable but unavoidable. Therefore, we must always
adjust both the upper and lower centric cusps (vs. Dawson's option\textsuperscript{12}) in order to minimize any widening of the occlusal table. Another reason why we must adjust both centric cusps in Quadrants 2 and 3 type of centric prematurities is that, as previously stated, we are organizing cusp and groove relationships for function in eccentric movements at the same time as we are adjusting centric relationships. This can only be accomplished by adjusting all of the centric cusps.

The combination of grooving and spheroiding or adjusting inner inclines produces the third criteria called "pointing" of the centric cusps. It is the pointing of the centric cusps which permits them to pass out through their opposing groove escapeways without having to destroy the morphology of opposing teeth by creating excessively wide grooves, which are anatomically and functionally incorrect (Fig. 8).

**INSTRUMENTS TO USE FOR ADJUSTMENTS**

In addition to knowing where and how to selectively grind teeth for occlusal equilibration, it is equally important to know what to grind with. We recommend an ultra high speed, round-end tapered fissure, 12-fluted carbide finishing bur such as a #7803 Midwest bur. This not only permits us to enhance the occlusal morphology by its small size and correct shape but also leaves the enamel and any restorative material as smooth as possible. This eliminates having to go back and spend time smoothing and polishing the adjusted areas which also might destroy the perfected occlusal stops (Fig. 9).
THE IDEAL OCCLUSION COMPROMISE

We realize that the ideal gnathological occlusion involves tripodized jaw closure stops in which the cusp tips never touch anything, anytime, anywhere, and we insist on this criteria when restoring a mouth with waxing and casting procedures. However, it is impractical to arrive at tripodized occlusal stops during occlusal equilibration, which is only a subtractive procedure. Therefore, our occlusal stops are located on the cusp tips, which oppose fossa whenever possible or occasionally on flat areas of marginal ridges.

There are three ways to unlock an occlusion or provide freedom of mandibular movement. One way, which is undesirable, is to provide perfectly flat cusp posterior teeth. Another way is the Gnathological approach of tripodized jaw closure stops coupled with immediate canine disclusion. The Pankey-Mann-Schuyler concept, which uses the cusp tips as jaw closure stops, incorporates some slight "long" and "wide centric" as the mechanism to unlock the occlusion. We can eliminate or minimize any long or wide centric even though we have the cusp tips as the jaw closure stops by pointing the centric cusps, perfectly organizing the ridge and groove direction, and by coupling the anterior teeth, especially the canines for immediate disclusion.

CONCLUSIONS

Successful occlusal equilibration is based upon the patient being neuromuscularly relaxed and symptom-free by means of biteplane therapy. Since not everyone can be equilibrated, it is important to diagnostically equilibrate accurately mounted casts and to keep a sequential grinding list prior to attempting intraoral selective grinding. Permitting the patient's own neuromusculature to seat the condyles in their respective tripodized superior position using a leaf gauge, permits the inexperienced as well as the experienced operator to adjust to true centric relation occlusion. Using the cusp-fossa analysis of opposing premature marks permits the operator to satisfy the gnathological criteria of occlusion. By adjusting the centric holding cusps rather than the shearing cusps and applying the principles of grooving, spheroiding, and pointing, an enhanced tooth morphology is easily accomplished. As centric is adjusted in this manner, the ridge and groove direction is organized for the eccentric excursive jaw movements at the same time that centric relation is corrected. This eliminates or minimizes the necessity of adjusting working and balancing eccentric interferences, making the procedure more efficient. Using a small round-end fissure finishing bur permits easy enhancement of occlusal morphology and leaves a smooth surface, eliminating the necessity of additional polishing which could destroy the centric stops.
A logical, efficient occlusal equilibration technique has been presented which satisfies the gnathological principles of occlusion. The technique is feasible, practical, and can be mastered by the inexperienced as well as experienced operator. It is one method of occlusal therapy which effectively helps the signs and symptoms of a pathological occlusion. It constitutes the most economical form of occlusal therapy. It is the most foolproof form of occlusal therapy because it can all be done on diagnostic casts prior to attempting any intraoral irreversible procedures. The immediate and continued relief of symptoms experienced by patients makes them appreciate the dental profession.


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