Many methods and theories have been employed in regard to treatment planning and correct restorative sequence. Assuming that the patient has healthy joints and a normal range of motion, the following steps can be helpful in sequencing treatment.

**Step 1: Vertical Dimension of Occlusion (VDO) Evaluation**

Initial evaluation begins with a subjective evaluation of VDO. A clinical observation is made as to whether the patient would benefit aesthetically with a change in vertical dimension. As restorative dentists we can alter the appearance of the lower facial third by changing the VDO; affecting the distance from the patient’s nose to chin. We know that the VDO is a balance between tooth contact position and muscle length. The contracted length of the masseter muscle is what dictates VDO. If the wear rate of the teeth exceeds the tooth’s ability to supra-erupt, then the VDO may be altered. An over-closed bite may present facially as a negative smile line and a collapse in the corners of the mouth. I refer to this as a “bitter beer face.” The first consideration for opening vertical dimension is based purely on improving facial aesthetics.

Consideration is then given to altering VDO for restorative reasons. From a clinical perspective, there are three reasons VDO may need to be opened.

**A. To increase incisal edge length.**

Opening VDO may be the only way to gain needed space to create a longer tooth.

**B. To gain restorative space.**

It is sometimes necessary to increase VDO to create enough space for restorations. Tooth preparation completed without having the appropriate space can result in the need for further tooth reduction that approximates the pulp. Likewise, additional space may be required to allow for restorative material following tooth preparation with proper resistance and retention.
tion form. By opening the VDO restoration length can be added without diminishing structural resistance or increasing the risk of pulpal encroachment.

C. To alter angle of disclusion.

The angle of guidance is determined by the inclines of the lingual contours of the maxillary anterior teeth as they relate to the mandibular incisal edges. The angle of disclusion is affected by the amount of anterior overbite and overjet. A deeper bite with a steep lingual incline of the maxillary anterior tooth is referred to as having a steep or higher angle of disclusion. Opening the VDO can alter this angle. Increasing the vertical space allows for the option of decreasing or flattening the angle of guidance or disclusion.

Step 2: Risk Factors

Symptoms of occlusal disease should be evaluated. The risk factors include the size of the masseter muscle, muscle and/or joint pain, limited range of motion, joint noise, tooth wear, cracks, chipping, dentin exposure, broken teeth, abfractions, recession and loss of attachment. Bite force is dictated by the size of the masseter muscle. Higher levels of force can create the potential for a guarded restorative prognosis. Patients that present with tooth wear or other occlusal disease also have the potential to wear restorative materials. Determining the existing risk factors and signs of occlusal disease is paramount in gaining insight to the restorative prognosis.

Step 3: Envelope of Parafunction

We have been taught to create our restorative solutions honoring the “envelope of function.” As an example, we have used “functionally generated paths” as a clue to final treatment solutions. It has even been suggested that all will be fine so long as there is canine guidance resulting in back tooth separation in lateral jaw movements, anterior coupling, and even distribution of occlusal loads.

This is simply not always true. Patients may present with an anterior open bite and uneven occlusal loading, yet they show no symptoms of occlusal disease. Conversely, there are patients with ideal tooth positions that honor ideal occlusal concepts yet they experience significant tooth wear or restorative failure. If ideal occlusal relationships exist, why do these breakdowns occur?

Patients come to the office with a chief complaint of a crown broken while eating. Studies indicate that when we chew, our teeth actually don’t touch. Teeth do not wear, chip or break when we chew, but rather at some other point in time. Not that functionally generated paths are unimportant—they are. But why does the crown or tooth wear or break? Is it from the stress and strain put onto the system when we go beyond normal chewing patterns? Teeth wear or break from the force we apply to the system in the envelope of parafunction. Teeth and most restorative materials hold up well under compressive loading. It is when shear loads are applied that occlusal disease symptoms become more evident. Parafunction is the pattern our jaw travels beyond normal functioning pathways. These parafunctional patterns create shear loads that result in a more guarded prognosis for teeth and restorative materials.

Cows and Gators

Each individual’s jaw goes through some pattern of motion evidenced in signs of occlusal disease. Some people have patterns of parafunction that are vertical in their pathway. This pattern is recognized as being up and down, or like a “gator.”

A gator’s vertical motions result in forces that compressively load the system. Tooth wear, dentin exposure, abfraction, and tori development are some of the signs and symptoms that
may develop in a gator. In extreme cases, these patients are so locked in that they are unable to move their jaw from side to side. This reduces shear loading but may still exhibit compressive loading wear patterns.

Another pattern is horizontal or side-to-side jaw movement. This is recognized as a “cow” pattern. A cow’s horizontal jaw motions result in a system that is laterally loaded with shear forces. This shear load may result in many symptoms such as wear facets, chips, cracks, dentin exposure, loss of tooth length, tori development, muscle pain or broken teeth. These shear loads create a higher risk of failure. Cows commonly have lost tooth length due to wear. As they parafunction side to side, enamel loss eventually becomes apparent. Anterior tooth wear can lead to a decrease in tooth length, which results in the loss of canine protected occlusion. This allows for increased shear loading of posterior teeth, contributing to a higher level of breakdown and an increase in muscle activity.

The reality is that individuals do not function as a cow or gator. Patients are generally somewhere in between.

The parafunctional pattern we develop will not change. As restorative dentists we will not alter the pattern our patient has displayed. If we create restorations that interfere with the established parafunctional pattern, the resulting
forces may contribute to further development of occlusal disease and failure will be imminent.

Suppose a patient presents with significant incisal wear and dentin exposure that has resulted in uneven incisal edges. The maxillary anterior lingual incisal edge is so worn that the enamel is thinned and has a very translucent appearance. To make the teeth more aesthetic, incisal length and thickness must be added. We can have the patient demonstrate their parafunctional pattern by bringing the mandible forward as though they are biting a thread. We can show the patient how these teeth fit together like a hand-in-glove.

By adding length or thickness to the incisal edge, we risk interfering with the patient’s envelope of parafunction. Will it fail? Maybe. If thickness is added to the facial incisal edge, then we may create a scenario where the tooth is too facial, affecting aesthetics, speech or infringing upon the wet/dry border of the lip. By adding length to the upper incisal edge, we risk putting restorative material into the parafunctional pathway. If loading forces are too high, breakdown may occur.

How can we predict the outcome? We have to consider the envelope of parafunction in conjunction with the risk factors listed above in step 2. If occlusal disease symptoms are significant, then parafunctional patterns create a heavier shear load. When muscle size is large our prognosis must be guarded. If occlusal disease symptoms are minimal then typically parafunctional forces are vertical which creates compressive loading. When muscle size is small our prognosis is better. The message is that we must attempt to create restorations that function within the envelope of parafunction.

Step 4: Incisal Edge Position

Incisal edge position needs to be considered from both a horizontal and vertical component. Its initial positioning is first based upon aesthetic demands. As we age, the upper lip tends to cover more of the upper incisal edge creating a perception of a more mature smile. Appropriate incisal edge display is best evaluated from a repose position. Lengthening the incisal edge can alter perceptions of age and beauty. Maxillary incisal edges that rest on the lower lip may be acceptable to some but not others. Incisal edge positioning should be evaluated on an individual basis and by no means does “one size fit all.”

Increasing incisal edge length may also increase the length of the parafunctional stroke without affecting the angle of disclusion. Even though the angle of disclusion is not altered, adding more length may violate the envelope of parafunction. Changes in the lingual contours of the upper anterior teeth resulting from the altered incisal edge length will alter the angle of disclusion. Steepening the angle of disclusion can result in a constriction of potential jaw movement. Putting the edge in the way of the parafunctional pattern can have adverse ramifications.

Step 5: Tooth Proportion

Once the desired incisal edge position is established, the length to width ratio is considered. A ratio of 4:3 is ideal for a maxillary central incisor with an average length of 10.5
mm. Tooth aesthetics are variable and should be considered on an individual basis. Tooth length may be increased or decreased with orthodontics or restoratively. Incisal edge position can be ideal, yet the proportion may be poor. To create a longer tooth without increasing incisal edge length, orthodontic intrusion followed by restorative addition can be completed in combination with crown lengthening. Restorative needs, crown to root ratios, and tooth/root anatomy are all factors that affect these treatment choices. After incisal edge position is identified, then the correct tooth proportion is considered, not the opposite.

**Step 6: Anterior and Posterior Reconstruction**

The alterations in VDO, envelope of parafunction, incisal edge position and correct tooth proportions influence treatment the most, so these factors should be determined first. For this reason, the anterior segment is restored prior to the posterior segment. It is the anterior tooth length and the clinically established angle of disclusion at a given VDO that dictates the posterior tooth contours.

A person who has a flat angle of disclusion will also have a flatter posterior occlusal table. A steeper posterior anatomy will result in interferences in lateral excursive movements. Someone with a steep angle of disclusion will have steep inclines on the posterior occlusal table. Inclines of posterior teeth should be slightly shallower than the determined anterior angle of disclusion; allowing for separation of posterior teeth while in lateral excursive movements. This reminds us of the importance of anterior coupling. Light passive contact of the lower incisal edge against the lingual of the maxillary anterior teeth has multiple benefits. It improves occlusal stability. If this contact is not present, then tooth movement, supraeruption or rotation of teeth can occur. Anterior coupling also has an inhibitory effect on the musculature. If anterior coupling is not present when the mandible travels into a lateral excursive position, the posterior teeth will interfere first. This will continue until the anterior contact occurs, initiating posterior tooth separation. Posterior lateral excursive interferences result in lateral shear loading of posterior structures and an increase in muscle activity.
Discussion and Clinical Application

Given the need to follow these six steps for each individual, how do we restore to the individual envelope of parafunction and achieve the desired outcome? The answer is easier than you might expect.

Diagnostic study casts mounted in centric relation are evaluated with condylar guidance established from a protrusive record. The condyles are released to allow maximum intercuspation. Next the pin is raised about 15 mm off the table. Sil-Tech\textsuperscript{®} lab putty is placed onto the anterior table and the models are closed into maximum intercuspation. The pin will indent into the soft lab putty. The casts are then moved through their parafunctional excursive patterns while the putty is still soft. This develops a custom parafunctional guide table.

Next a diagnostic wax-up is completed. The goal is to complete this without the pin coming off the table. If the pin leaves the table then the case is being restored outside the envelope of parafunction. Can this always be accomplished? No. If desired incisal edge length is such that it forces treatment outside the envelope of parafunction, then the factors in step 2 become paramount. If a patient does not have symptoms of occlusal disease, but has a vertical pattern of parafunction, then the prognosis is reasonably good. If occlusal disease factors are evident, the patient has heavy muscle force and a horizontal parafunctional pattern, then the prognosis is guarded.

One alternative is to open vertical dimension. This allows for a longer tooth or incisal edge, without the pin leaving the table. This can be considered if one or both arches need to be restored.

Step 7: Laboratory Communication

It is pointless to determine the appropriate VDO, incisal edge position, aesthetic contours, angle of disclusion and posterior tooth contours if the laboratory product is not consistent with the developed determinants. Digital photography of pretreatment, preparations and provisionalization are helpful tools in communicating with the laboratory technician. An additional invaluable tool is the utilization of cross-mounted models.

Alginate impressions should be taken of the provisionalized case. Because the case is treated in segments, bite registrations are also taken in segments. Envision a case where provisionals are made with 3 sections for each arch: tooth \#’s 2-5, 6-11, 12-15, 18-21, 22-27, & 28-31. Once all the provisionals are in place, temporary \#’s 6-11 are removed and a bite registration is taken. Next, temporary \#’s 2-5 are removed and a bite registration is taken. Temporary \#’s 12-15 are removed and a bite registration is taken. Then there are three different bite registrations that record upper preparations against lower provisional restorations. Next all of the provisionals are replaced and temporary \#’s 22-27 & 6-11 are removed and a bite registration is taken. Temporary \#’s 28-31 & 2-5 are removed and another bite registration is taken. Finally temporary \#’s 18-21 & 12-15 are removed and a bite registration is taken. This creates three different bite registrations that record upper preparations against lower preparations.

Utilizing the impressions with the temporaries in place (cross-mounted cast) and the prepared master casts, models can be mounted so they are all completely interchangeable. The segmental bite registrations are used to complete mountings. A face bow is taken and the upper master cast is mounted. Next the bite registrations that recorded the maxillary and mandibular preparations are positioned and the mandibular master cast is mounted. Then the mandibular mounting is removed from the articulator, the bite registration recording the maxillary preparations with the mandibular provisionals is put in place and the lower provisional model is mounted. Finally the maxillary master cast is removed and the maxillary provisional model is articulated and mounted against the mandibular provisional
Mounted models

1. Maxillary preparations articulated with mandibular preparations

2. Maxillary preparations articulated with mandibular provisionals

3. Maxillary provisionals articulated with mandibular preparations

4. Maxillary provisionals articulated with mandibular provisionals

Completed restorations
model. Now there are four mounted models that are completely interchangeable.

The technician can cross mount accurately to the preparations with all of the transferred diagnostic information. Incisal edge position and length, the upper anterior lingual contours that dictate angle of disclusion, overbite, overjet, curve of Spee, curve of Wilson, occlusal scheme and contacts and anterior and posterior anatomy are all represented. Indexes can easily be constructed from these models. Sil-Tech® can be used to make a facial index of the upper anterior provisionals and transferred to the preparation model to verify needed reduction. An occlusal index is constructed registering the occlusal and incisal edges of the upper teeth. This is done by simply placing Sil-Tech® over the mandibular model and closing the maxillary provisional model into the material. This registers these incisal/occlusal contours. The registration is then trimmed to reveal these areas and the maxillary preparation model is placed onto the articulator. When it is closed with the pin on the table a space exists between the preparation and the index. This index now reveals the space present and all of the contours that must be established leaving no guesswork for the technician.

In conclusion, the evaluation of these steps individualizes treatment based upon the patterns that each patient has developed. By creating restorative solutions that do not interfere with the envelope of parafunction, management of forces on the patient’s system can be optimized while considering the aesthetic ramifications.

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