Excellence In Finishing:
Current Concepts, Goals And Mechanics

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Abstract
It has been widely recognized for many years that proper finishing is of critical importance in achieving an excellent occlusal result after orthodontic appliance removal. This clinical presentation deals with defining finishing goals and achieving them with the appropriate treatment mechanics for optimal esthetics, function and stability. It highlights certain occlusal — static and dynamic — periodontal as well as aesthetic parameters that provide useful guidelines for finishing in both the adolescent and adult orthodontic patient.

Keywords
Finishing goals, occlusal parameters, periodontal factors.

Introduction
Stability of the orthodontic treatment result has been a topic of great interest to the profession since the inception of our specialty. The improvements in the position of teeth achieved after great deal of effort may be lost to varying degrees, after the removal of orthodontic appliances. Sometimes changes in tooth positions are noticed even during the period when the patient is using retention appliances. It has been recognized for many years that the stability of orthodontic treatment results at least partially depends on the way cases have been finished1. Orthodontic finishing still remains a continual challenge for the Orthodontist. Preadjusted Edgewise Appliances in their current variations probably represent the biggest step up the orthodontic evolutionary ladder and provide great benefits to Orthodontists in all stages of treatment, especially during finishing and detailing. However, in some clinical situations, it requires a great deal of effort and skill to achieve an excellent occlusal result after appliance removal.

This clinical article deals with defining finishing goals and achieving them with the appropriate treatment mechanics for optimal esthetics, function and stability. It highlights certain occlusal — static and dynamic — periodontal as well as aesthetic parameters that provide useful guidelines for finishing in both the adolescent and adult orthodontic patient.

It is author’s belief that the orthodontic finishing begins with diagnosis and treatment planning. With advances in treatment mechanics, there is hardly an abrupt stage of complicated wire bending to fine tune the tooth positions; rather it is a gradual progression toward finishing. In the management of a routine orthodontic case, it is extremely important for a clinician to define finishing goals at the beginning of treatment and continue to focus on them till the finishing stage, in order to achieve them with appropriate treatment mechanics. The generally accepted treatment objectives are as follows:1-3:

1. Normal static occlusal relationships - Class I occlusion with “Six Keys”, 3mm of overjet and overbite
2. Normal functional movements - a “mutually protected occlusion”
3. Condyles in a seated position - in centric relation
4. Relaxed healthy musculature
5. Normal periodontal health
6. Optimal esthetics
7. Long-term stability of posttreatment tooth positions

The purpose of this presentation is not just to outline treatment goals and discuss them in detail. It is the intent of this presentation to inform the orthodontic clinician of the importance of occlusal, periodontal and esthetic parameters, to finish orthodontic cases to the highest standards.
Static occlusal parameters

Alignment

Proper alignment of teeth has been a fundamental objective of any orthodontic treatment approach. In July of 2000, the American Board of Orthodontics further clarified and quantified the static occlusal goals by providing a grading system for study casts and panoramic radiographs. In the mandibular arch, the labioincisal edges of the incisors and canines are the determinants of anterior alignment. This is because when labioincisal edges are aligned properly, the teeth look the best esthetically and they are the functioning surfaces of the mandibular anterior teeth. In the maxillary anterior segment, the lingual surfaces of the maxillary incisors and canines are used as a guideline to establish proper alignment. This is based on the fact that, these surfaces are the functioning surfaces and when aligned properly, the anteriors appear to be in their best esthetic relationship.

In the mandibular posterior segment, the buccal cusps of mandibular premolars and molars represent the functioning surfaces and they are easy to visualize intraorally. Therefore, these landmarks are used to establish the proper alignment in the posterior segments, within the patient’s acceptable archform. In the maxillary posterior segments, central grooves of the maxillary premolars and molars are used to assess proper alignment. Again, these are used since they represent the functioning surfaces of the maxillary posterior teeth, and are easy to observe intraorally.

Marginal Ridges

The marginal ridges can be used as a key to achieve relative vertical positioning of the posterior teeth. During the finishing stage, it is important to make sure that the marginal ridges of adjacent posterior teeth are positioned at the same level (Fig. 1). This will position the cusps and fossae of those teeth at the same level. Once the marginal ridges of the posterior teeth are positioned at the same relative level, then the cementoenamel junctions are also at the same relative level. This will lead to the bone levels between the adjacent teeth being flat, producing a much healthier periodontal situation for the patient.

The lack of distal root tip in the maxillary second bicuspids expressed during the finishing stage leads to discrepancy in the marginal ridge matching between these teeth and the first molar. This also leads to a lack of occlusal contact in the posteriors.

Transverse relationship of posteriors

During the finishing stage, it is of paramount importance to evaluate the buccolingual inclination of the posterior teeth to achieve good intercuspation and prevent interferences during mandibular movements. This should be assessed by evaluating the relationship between the buccal and the lingual cusps of the maxillary and mandibular premolars and molars — called the ‘Curve of Wilson’. In normal situation, the lingual cusp should be at the same level or within a millimeter of the same level as the mandibular buccal cusps. This relationship makes the occlusal tables of posterior teeth relatively flat, therefore, promoting better contact of the maxillary lingual cusps with the fossae of the mandibular posterior teeth.

The extreme amount of mandibular posterior lingual crown torque found in many preadjusted appliance prescriptions leads to “rolled-in” mandibular posterior teeth as a result of expressed torque (Fig. 2).

In the maxillary buccal segment, the palatal cusps of the first and second molars are generally slightly longer and extend slightly more occlusal than the buccal cusps. With the common use of expansion treatment often using over-expanded, commercial arch blanks or a limited amount of maxillary posterior expressed buccal root torque, palatal cusps extend occlusally beyond their normal limits (Fig. 2). This promotes inappropriate interdigitation between maxillary and mandibular posterior teeth, producing cross arch balancing interferences in the lateral mandibular excursions. Therefore, the buccolingual relationship of posterior teeth should be improved by flattening the curve of Wilson, minimizing or eliminating the discrepancies in the posterior overjet, and avoiding the prominence of palatal cusps by reducing the lower posterior torque and increasing the upper.
Fig. 2: Establishing static occlusal parameters.
Anterior Inclination

Optimal positioning of maxillary and mandibular incisors at the conclusion of treatment is the prime objective of any orthodontic treatment plan (Fig. 4&5). Also, the control of undesirable incisor movement inherent with the routine orthodontic treatment mechanics would reduce amount of fine-tuning of incisor position during the finishing stage. AlQabandi et al. reported 6°-7° of lower incisor flaring when simply leveling the curve of spee with fixed appliances. Reports have described the limitations of controlling the labial proclination of lower incisors during leveling, even with rectangular wires, especially when using class II elastics.9,10

Raleigh Williams11, suggested certain guidelines to optimally position mandibular incisors and canines for long-term stability. The lower incisor apices should be spread distally to the crowns, and the apices of the lower lateral incisors must be spread more than those of the central incisors (Fig. 6). Apex of the lower cuspid should be positioned distal to the crown. All four lower incisor apices must be in the same labiolingual plane. The lower cuspid root apex must be positioned slightly buccal to the crown apex.

The overall inclination of the maxillary and mandibular anterior teeth is best evaluated with a lateral cephalometric radiograph. The interincisal angle plays an important role in esthetics, function and stability and should not be based on averages.12 Growth direction, esthetics and overbite should also be considered in determining ideal torque in the maxillary and mandibular arch. In short, it should be individualized.

If uncontrolled flaring of the lower incisors is permitted, then increased labial crown torque of the maxillary incisors would be required to maintain appropriate overbite/overjet and in the process, more bimaxillary protrusive results will be produced, which will be detrimental to facial esthetics.

Molar position

Insufficient thickness of maxillary second bicuspids causes first molar to rotate mesially upon initial wire engagement, causing an increase in Class II tendency.
Fig. 3: Limited amount of maxillary posterior buccal root torque and the extreme amount of mandibular posterior buccal root torque, leading to improper interdigitation, increased buccal overjet, and balancing interferences. (Courtesy - Dr. Jay Bowman)

Fig. 4: Improved buccolingual relationship of posterior teeth by reducing the lower posterior torque and increasing the upper.

Fig. 5: Normal interincisal relationship, overjet and overbite achieved by optimal incisor torque control.

Fig. 6: Optimal lower incisor positioning with progressive distal root spread.

Fig. 7: Position of maxillary second bicuspid - a key to a properly treated malocclusion.

Fig. 8: Proper location of contact points.
and buccal movement of second bicuspid. Also, the marginal ridge discrepancies between the maxillary and mandibular first and second molars may result from difficulties in posterior appliance placement due to limited visibility, variable clinical crown height, delayed eruption of teeth, and gingival hypertrophy.6

Sondhi 13 demonstrated the production of "inappropriate or broken contacts between mandibular first and second molars" due to the distal offsets of the first molar attachment found in some popular prescriptions. This offset can displace second molars to the lingual and/or rotate the first and second molars to the mesial, thereby, creating an incorrect match of the adjacent marginal ridges and contact points.

These discrepancies of treatment must be carefully evaluated and addressed during the finishing stage in order to promote proper proximal contacts, marginal ridges and alignment in the buccal segments.

Maxillary second bicuspid – a key to occlusion

Ricketts 14 pointed out that the contact position of the maxillary second premolar is a key to a properly treated malocclusion. The maxillary second premolar should have a normal contact relation with the mesial incline of the lower first molar which produces an interlocking into the corresponding interspaces of the lower premolars (Fig. 7). This relationship causes the tip of the mesiobuccal cusp of the upper first molar to be slightly distal to the mesiobuccal grove of the lower first molar. According to Ricketts this is the most efficient, most self-cleansing and most self-preserving relationship in accordance with Nature's plan.

Contact points

The importance of proper contact points between the teeth in preventing food impaction and stability of the dental arches after orthodontic treatment has been well understood by all specialists. During the finishing stage, three dimensional control of teeth positions and their relationship with the adjacent teeth is essential to establish the location of contact points. Contact points or contact surfaces of teeth are generally located in the occlusal one third of the proximal walls, slightly buccal to the central fossa in the molar and premolar area with the exception of the maxillary first and second molars 15,16 (Fig. 8). The contact point between the maxillary central incisors is located at the most incisal one third having a perception of a vertical line. The position of contact points in the maxillary anterior segment, when viewed from front, seems to progress from the incisal to cervical, from the central incisors to the canine (Fig. 8).

Contact points must be observed from two aspects in order to obtain the proper perspective for their proper location; the labial or buccal aspect, and the incisal or occlusal aspect.

Occlusal contact

After the resolution of malocclusion, teeth need to be individually settled into their final positions before appliance removal. In the posterior segment, teeth are generally held away from each other in vertical plane due to full size rectangular stainless steel finishing archwires. The vertical settling of maxillary and mandibular teeth to achieve maximum intercusaption is done by using different configurations of vertical elastics. The more precise the placement of brackets and tubes, the easier it is to settle the teeth and the less elastics need to be used in this way. The adequacy of posterior teeth interdigitation is evaluated by assessing the contact relationship between the cusps and fossae of the molars and premolars. Ricketts 14 pointed out that, without third molars, 16 to 24 occlusal stops or centric stops on each side are adequate for a good balanced occlusion.

The lingual cusps of the maxillary premolars and molars should be in contact with the marginal ridges or fossae of the mandibular premolars and molars 4. In addition, the buccal cusps of the mandibular premolars and molars should contact the fossae or marginal ridges of the maxillary molars and premolars 4. Due to lack of an adequate occlusal table, the lingual cusps of the maxillary first premolars may not establish contact with the mandibular first premolar.

Dynamic occlusal relationships

In addition to achieving the occlusal relationships in Class I as suggested by Angle 17 and the 'six keys to occlusion' by Andrews 18, other workers like Williamson 19, Aubrey 20, Ricketts 21, and Roth 22 have all expanded the area of knowledge in occlusion to include the neuromuscular and bony structures of the TMJ in establishing orthodontic treatment objectives. In dealing with the various elements of functional occlusion as one of the finishing goals, it is important
Fig. 9: Establishing functional occlusal goals

C - Mandibular right lateral excursion, D - Protrusive mandibular movement, E - Mandibular left lateral excursion.
Fig. 10: Post-treatment intraoral and extraoral photographs.

Fig. 11: Cephalometric tracings
  A - Pre-treatment
  B - Post-treatment
  C - Pre and Post-treatment superimpositions
to achieve stable centric relation of mandible with maximum intercuspatation of the teeth at this position. In the intercuspal position and retruded contact position the mandible should be situated in the same sagittal plane, the distance between the two positions being less than 1mm.

There should be harmonious glide path of anterior teeth. These teeth should work against one another to separate or disclude the posterior segments as soon as the mandible moves out of centric closure. The proper overbite and overjet established after orthodontic treatment should allow for a gentle glide path.

The canines should provide the main gliding inclines for lateral excursions, with no interferences on the balancing side (Fig. 9). The six mandibular anterior teeth and mandibular first bicuspids should articulate with the maxillary six anterior during mandibular protrusive excursion. In this way, a protrusive load is spread over fourteen anterior teeth with no interferences in the posterior region (Fig. 10). The teeth should not prevent the mandible from entering or leaving any possible position that the joints will allow. Therefore, the teeth should direct and maintain the centricity of the condyles in their fossae on closure.

Interincisal relationship – a critical element of functional occlusion

The optimal position of maxillary and mandibular incisors and their relationship with each other after orthodontic treatment is one of the key elements of functional occlusion. According to McHorris,23,24 in the optimal functional occlusion, the anteriors are in very close approximation but do not touch when molars are in occlusion. The lower anteriors engage the lingual incline of the opposing upper anteriors immediately with mandibular movement. The lingual discluding surface of the upper anteriors seems to reflect the anatomical angle of discluding pathway of the mandibular condyles. The ideal anterior disclosure angle is greater than or equal to 5 degrees than the condylar disclosure angle (Fig. 11).

An occlusal interference on the anterior teeth, identified during unforced closure of the mandible, sometimes associated with a distalizing effect in condylar position has been termed as “anterior interference.”25 The axial inclinations of maxillary and mandibular anteriors and the consequent interincisal angle should be proper in order to avoid anterior interferences after orthodontic treatment.

Fig. 12: The ideal angle of disclusion in protrusive is thought to be 5 degrees greater than the condylar disclusive angle.

Periodontal Factors

One of the finishing goals of orthodontic treatment is to position the roots of adjacent teeth parallel to each other. Other factors being normal, if the roots are parallel to each other, then there will be sufficient bone between the roots of teeth. It is considered that more interproximal bone will provide greater resistance to periodontal bone loss if the patient develops periodontal disease in the future. During the finishing stage, if the teeth are not properly uprighted, especially when the second bicuspids or first molars are extracted/missing and the posterior teeth are drifted into that space; then the marginal ridges will not be level, proximal contacts will be faulty, with angular bony defects on the mesial aspects of the mesially tipped teeth.

Another clinical situation which demands parallelism of roots of the adjacent teeth is when the maxillary lateral incisor is missing. If the maxillary lateral incisor is missing and the treatment plan involves sufficient opening of lateral incisor space and subsequent restoration with an osseointegrated implant, then it is important to evaluate the position of the roots of adjacent teeth radiographically. The roots of the central incisor and canine should be parallel to each other with adequate space between the roots for implant placement.

Crown Width Discrepancy

Size of the teeth is one of the most important elements of anterior dental esthetics. Orthodontists are often faced with disproportionate widths of anterior teeth during treatment. This tooth size discrepancy is
commonly found in patients with peg-shaped lateral incisors. Even after getting the teeth perfectly aligned and the arch forms properly established with orthodontic treatment, the abnormal shape and smaller size of lateral incisor pose esthetic problems.

The Golden proportion can be called the building blocks of nature itself. This ratio is an ideal ratio that can be mathematically defined as 1:1.618 (Fig. 12). It has been observed that when this rule of good proportion is followed, the result is something that is naturally attractive and pleasing to the eye. Smiles can be made attractive by following these mathematical rules of nature to create harmony, symmetry, and proportion.16,27

We can use the proportion to define the length: width for each tooth. Also the width of central incisor is in golden proportion to the lateral incisor which in turn is in proportion with the mesial width of the Canine26.

![Diagram of Golden proportion](image)

**Fig. 13:** The Golden proportion-an ideal ratio can be mathematically defined as 1:1.618.

It is therefore imperative to restore the size of the malformed lateral incisors after the completion of orthodontic treatment for good overall treatment result (Fig. 13 & 15). During the finishing stage of orthodontic treatment, if excessive space exists in the anterior segment, it should be redistributed to restore the proper crown width (Fig. 14). If insufficient space exists to restore these teeth, an adequate space should be gained which will permit the restoration of proper crown width. To determine the space required to restore the crown width, during the treatment planning stage, construction of a diagnostic wax-up is an important step to visualize the final result. After removal of the fixed orthodontic appliances, provisional restorations should be given before final restorations to avoid relapse.

**Replacement of missing laterals with implants**

Dental agenesis occurs quite frequently, especially of the maxillary lateral incisors, and it presents a true challenge to an esthetic solution. For a long time, many clinicians had suggested an alternative treatment approach by moving the entire lateral segment mesially to place the cuspid in the lateral incisor position. However, this approach ends up with compromised results that do not fulfill the esthetic requirements of good orthodontic treatment, since the cuspid has a very different crown and root shape to that of the lateral incisor, as well as a darker shade. When missing lateral incisor space is closed by moving the entire lateral segment mesially, lateral excursions are made using bicuspids, which have shorter, thinner roots; thus, functional requirements are also not fulfilled either.

If fixed restoration is the treatment of choice, it requires reshaping neighboring teeth, with consequent removal of varying amounts of enamel, and eventual risk of gingival recession, caries etc. The osseo-integrated implant is the most conservative and biological method, since the missing tooth can be replaced without damaging the neighboring teeth.

If the use of implants is the part of treatment plan for the missing lateral incisors, it is necessary to decide the exact placement of implants, evaluate the smile line and gingival contour. When the lateral incisors are missing, there is usually no adequate space to restore them due to drifting of the adjacent teeth (Fig. 16). In such cases, it is essential to gain adequate space with orthodontics for the placement of implant and crown restoration for good esthetic result (Fig. 17). The exact amount of space created should be according to the proposed size of lateral incisors, which should be proportionate to the width of the central incisors. After opening up of sufficient space, acrylic teeth may be selected closer to the shade of the patient’s teeth, bracketed and attached to the arch wire for esthetic purposes. Before the orthodontic appliances are removed it is important to evaluate radiographically the position of the roots of adjacent teeth.

The roots of the central incisors and canines on either side in case of bilaterally missing laterals should be parallel to each other with adequate space between the roots for implant placement (Fig. 18 & 19). Before removal of orthodontic appliances, it is common to see adequate space for the prosthesis and inadequate space between the roots of the adjacent teeth for an implant. This usually occurs due to tipping movement of adjacent teeth, which requires proper uprighting of the roots during the finishing stage of orthodontic
Fig. 14: Class 1 malocclusion with disproportionate crown widths of anteriors due to peg-shaped laterals.
Fig. 15: Proper distribution of anterior spaces to restore normal widths of lateral incisors.
Fig. 16: Peg-shaped laterals are restored with ceramic veneers in a golden proportion with adjacent teeth.

Fig. 17: Maxillary lateral incisor is missing and the adjacent teeth are drifted into the space.
Fig. 18: Sufficient space has been created orthodontically to restore maxillary right lateral incisor.
Fig. 19: Intraoral periapical radiograph shows adequate space between the roots of the central incisor and canine. Note the parallelism of roots of the adjacent teeth.
Fig. 20: Osseointegrated implant placement in the lateral incisor region.

Fig. 21: Normal gingival architecture.
Fig. 22: Faulty maxillary anterior restoration violating the biologic width and discrepancy in gingival margins and gingival zenith.
Fig. 23: After the differential forced eruption of incisors, the crown extension procedure has been planned on upper right central and lateral incisors to resolve the residual gingival discrepancy.
Fig. 24: The combined orthodontic and restorative treatment exhibiting normal gingival architecture with physiologic positioning of finishing margins of anterior restoration.
During the process of eruption the appearance of the gum is carried with the erupting tooth. When there is asymmetric eruption of the teeth it will also result in discrepancies in heights of the underlying crestal bone. This, in turn, results into asymmetries in gingival heights (gingival zenith) from one side of the arch to the other. This type of a clinical situation can be managed orthodontically by intrusion or extrusion of teeth (Fig. 21, 22 & 23).

Conclusion

Modern orthodontic treatment is aimed at creating the best possible occlusal relationships within the framework of acceptable facial esthetics and stability of the occlusal result. It is extremely important for a clinician to define finishing goals at the beginning of treatment and continue to focus on them till the finishing stage, in order to achieve them with appropriate treatment mechanics. This article has provided certain occlusal - static and dynamic - periodontal as well as esthetic parameters that outline useful guidelines for finishing in both the adolescent and adult orthodontic patient. Also, choosing the best possible treatment options from other specialties and combining them as a part of the optimal treatment plan based on scientific rationale should be the aim for the benefit of the patient.

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References