

Borderline Orthodontic Cases - Diagnosis and Management: A Review

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Abstract: *Borderline cases are in which the tooth size arch length discrepancy lies between extraction and non extraction range, therefore there is always an uncertainty of attempting extraction. Because such cases have balanced face and pleasant profile, there is no set of values which can infallibly spell out treatment procedure. We must consider growth potential or possibilities of treatment as well as limitations. Conflicting interests are weighed with the desirability of a stable result from the standpoint of the arch length problem and the possibility of improvement in lip and lower face contour by retaining all dental units. Extractions may be assorted to at the discretion of the operator. Many considerations are necessary to decide on a borderline case. No single diagnostic criterion can be relied upon. The desired final location of teeth is predicated upon satisfying esthetics, functional balance, and essential stability following retention procedures. All three requirements are equal and of commensurate importance. It is necessary to project and visualize treatment procedures, results of active treatment and the amount of expected post retention stability. Consequently this exercise projects treatment in terms of time since time is the ultimate judge.*

Keywords: Orthodontics, Borderline cases, Dilemma, Diagnosis, Management

1. Introduction

“A case is border line when extraction of permanent teeth is required to reach a stable and functional occlusion, but when the patient has good facial esthetics that could be disturbed by extractions.”¹ “Empirical evidence of uncertainty exists with these patients.”² Because non extraction treatment can protrude the incisors and extraction can land up in dish in face, Therefore there is great divergence of opinion in the treatment of such patients. Borderline cases may also have an absence of dental or craniofacial anomalies, permanent dentition, healthy periodontium and normal anteroposterior relationship between maxilla and mandible. This dilemma of extraction or non extraction always troubles the orthodontist and requires a careful diagnosis.

Historical perspective: Extraction deciduous teeth to create space for accommodation of the remaining teeth of crowded dental arches was written in the dental literature as long as 1771. There was little or no opposition to extraction of deciduous teeth to clear the way for permanent successors when Celsus and Pierre Fauchard recommended it. However, few dentists started extracting permanent teeth also as there was requirement of more space. Hunter³ in 1771 was in disagreement and gave the clarification that with the extraction of permanent teeth; there is a chance of growth inhibition. In 1907, Edward H. Angle professed that moving teeth into normal occlusion with orthodontic forces would cause the jaws and associated bones to grow to accommodate the increased size of the dentures.⁴ In contrast, Calvin Case⁵ argued a few years later that, although most malocclusions could be treated without extractions, the objective of stability was often not achieved. The battle commenced in 1911 that culminated as "The Extraction Debate of 1911." In 1952, Charles Tweed, a student of Angle, presented a paper advocating the extraction of all four first premolars⁶, using cephalometric analysis to support his position. During the same period, Raymond Begg⁷ in

Australia was developing an appliance system based on therapeutic extraction as well. The era of 1970-1990's saw the revival of nonextraction treatment. Studies by Little et al⁸ in 1981 and Mc Reynolds et al⁹ in 1991, supported the fact that premolar extraction does not guarantee stability of tooth alignment. Subsequently, facial harmony and esthetics was given more importance by orthodontists thereby reducing the rate of indiscriminate premolar extractions.

Diagnosis: Diagnosis is made on the basis of clinical examination, cast analysis and cephalometric analysis.

Clinical Examination: important parameters are

- Profile- in borderline cases profile or facial aesthetics¹ of the patient is mostly acceptable and not a problem. Major change in the profile of the patient is not required because all the cephalometric findings will be within normal range.
- Size of nose and chin- If nose is very prominent, non extraction plan will be suitable because extraction and retraction will further make the nose more prominent. Arnett¹⁰ Nasolabial angle - If it is large (Arnett analysis) go for non extraction treatment.
- Buccal corridor¹¹- On smiling if patient has negative black/dark spaces between his cheek and buccal surface of the teeth. Then non extraction treatment may be reasonable.
- Facial form¹²- Brachecephalic facial pattern might have retruded mandibular dentition. characteristic feature of this is deep inferior labial sulcus combined with hypertonic masticatory and facial muscles. If patient is Brachecephalic and we are extracting the teeth then burning of anchorage may be a problem. Such cases may require nonextraction treatment.
- Lip morphology: Lip separation – increases with tooth prominence, Thick, full lips, Lip strain i.e. lack of well defined labiomental sulcus.

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Cast Analysis:**Tooth-size arch length deficiency (TSALD)**

TSALD is the most common form of malocclusion treated by orthodontists. Carey has set 2.5-5mm TSALD as a borderline case.¹³ McNamara set arbitrary borderlines of 3-6 mm.¹⁴ Gust, concluded "amount of maxillary arch length discrepancy may range from 6 to 8-11 mm for borderline cases.² Roughly 1 mm of crowding in either arch to constitute definitive nonextraction, while for definitive extraction therapy in the maxillary and mandibular arches it was 5.8 and 7.3 mm, respectively.¹⁵

Curve of Spee

One popular rule of thumb is that 1 mm of arch circumference is needed for each millimeter of curve of Spee depth present.¹⁶ Recent studies conclude the real effect to be closer to 1:3; for every 3 mm of curve leveled, arch circumference increases by 1 mm.¹⁷ According to Woods,¹⁸ the amount needed is variable depending on the type of mechanics used. The deeper the curve of Spee, the greater the need for extraction. Roth considered 3-6 mm of curve of Spee mild (1.5-3.0 per side),¹⁹ and Baldrige added that greater than 6 mm is severe.¹⁶ Other important factors that should be considered in leveling are lower facial height, incisor show or display, remaining growth of the patient.

Bolton's discrepancy²⁰

In order to achieve a good occlusion with the correct overbite and overjet, the maxillary and mandibular teeth must be proportional in size. Bolton (1958) noted a Tooth Size Discrepancy of up-to 4 mm to be a limit of the anterior reduction. Extraction may be necessary to resolve a discrepancy greater than this.

Peck and peck analysis²¹

Peck and peck analysis is calculated as MD length of mandibular incisor divided by its labiolingual width. MD and faciolingual (FL) index values for mandibular central incisor is 88-92 and for mandibular lateral incisors is 90-95. Patients with MD/FL indices above the desired ranges may be candidates for the reproximation.

Irregularity index

Little developed the irregularity index and calculated mandibular anterior irregularity by adding the linear distances between the five adjacent anterior contact points. With perfectly aligned incisors, the score is zero. Little noted a score >6.5 mm indicates severe irregularity and, thus, the greater likelihood for extraction.²²

Expansion: If the arch is narrow or any crossbite is present then check the possibility of expansion by Pont's analysis and Ashley howe's analysis. If calculated width is greater than the measured width then expansion is possible. It should be done in CVMI - 1 or CVMI - 2 stage (In prepubertal period). Because pubertal or post pubertal timing entails more dentoalveolar effects.

Cephalometric Analysis**Skeletal variables**

Vertical dimension is the most important to the clinician. Two important angles for the assessment of vertical

dimension are Sella-Nasion and mandibular planes (SN-MP) angle²³ and FMA angle.²⁴

SN-MP angle formed at the intersection of the SN-MP with the average value of 33° for balanced vertical facial types, with a range of 31-34°. The normal value for the FMA is in the range of 20-30°. Values above these normal ranges are associated with skeletal open bite, whereas values below are typically associated with skeletal deep bite. Treatment geared toward achieving facial balance is more likely to extract in skeletal open bite and not extract in cases with skeletal deep bite.

Dental variables

Incisor mandibular plane angle (IMPA): Charles tweed noted a need for "upright" and "vertical" lower incisors to create facial balance and harmony. He proposed IMPA to be 90° ± 3° in normal, balanced faces. According to tweed, this value can range between 85° and 95°, and vary according to ethnicity.²⁴ Values above this range are indicative of extraction to improve functional and esthetic imbalance.

Point A to Pogonion (A-Pog) line McNamara found the proper position of the mandibular incisor to be 1-3 mm anterior to a line from point A-Pog in a well balanced face, regardless of age.²⁵

Maxillary and mandibular incisor from Nasion to A and B point respectively: Steiner set the ideal positions of the maxillary and mandibular incisors to be 4 mm anterior to the lines connecting Nasion and point A, and Nasion and point B, respectively.²³ The maxillary and mandibular incisors should form angles of 22 and 25° to their respective diagnostic lines. Extraction becomes more likely as incisor positions and angles exceed these values in horizontal planes.

Soft tissue

Pleasing soft tissue profile should be the main focus of orthodontic diagnosis and treatment planning. Position of upper and lower lip : A borderline case with pre-treatment lip protrusion may be better served with extraction. Similarly, a more retrusive profile may be improved without removing teeth. Ricketts first identified the esthetic plane, relating lip position to a line from the nasal tip to soft tissue Pogonion.²⁶ In the adolescent, the lower lip is about 2 mm behind the esthetic plane, or E line and the adult lower lip about 4 mm. Burstone found it advantageous to consider lip position relative to a line connecting subnasale and soft tissue pogonion because it is based on a "plane of minimal variation in the face."²⁷ The author noted the nose is an area of great variation. Since lip protrusion can disrupt an otherwise pleasing face, extraction may be necessary the further a patient is from the ideal. For each 1 mm of retraction of the upper incisor, the upper lip retracts 0.75 mm.²⁸ Talass et al. found lower values for this ratio which is 1/0.64.²⁹ On the other hand, lower lip retracts by 0.6 mm for every 1 mm of lower incisor retraction.³⁰ Thus, retraction of anterior teeth for space closure makes the profile more concave.

Naso labial angle : According to Burstone's²⁷ evaluation of lip relation, a preferable nasolabial angle value is 73.8° ±

8°. More recent studies find more suitable values in the range of 90-115°. ^{26, 31} Extraction of four bicuspids was noted to increase the nasolabial angle by 5.2° as noted by Drobocky and Smith. ³² Therefore, extraction of teeth in a borderline patient with a nasolabial angle greater than the normative values should be avoided.

Lip prominence

Holdaway's soft tissue analysis ³³ includes linear measurements to assess upper lip morphology and strain. The thickness of upper lip should be measured in two different areas: 3 mm below skeletal point A, and from the vermilion border to the labial surface of the maxillary central incisors. In normal patients, these two measurements should be approximately the same (± 1 mm). If the vermilion border is thinner than the upper lip near point A, the lip are considered strained. If the upper lip is thinner than the vermilion border, the lips are considered flaccid. In strained lips, the incisors can be retracted without altering the soft tissue profile because the lip needs to reach normal form and thickness before they are retracted. In such patients, extraction is indicated. On the other hand, the lips would immediately follow tooth movement in patients with normal lips. According to Arnett and Bergman ¹⁰, orthodontists should avoid extraction in patients with flaccid lips due to the lack of labial support and the potential for esthetic problems.

Midline deviation ^{34, 35}

Proper assessment of facial, skeletal, Functional and dental symmetry is essential in orthodontic diagnosis. Evaluation of the dental midline should be assessed with respect to the face. A deviation of the dental midline(s) may indicate a skeletal asymmetry and require surgery for correction. Severe dental midline deviation relative to the face (especially in the lower arch) requires tooth extractions. Minor shift in midline can be corrected with the use of intermaxillary elastics or mini-implants (in some cases, unilateral mechanics), asymmetric extractions, stripping. For functional we can use deprogramming splint. The literature provides little data on the quantity of deviation relating to the borderline of extraction.

Growth status

It is very important to keep in mind the facial growth status of the young patient; particularly those with malocclusions of skeletal origin. Cervical vertebrae maturation index (CVMI) can be used to assess an individual's skeletal age. Growth of the soft and hard tissues has a significant influence on the facial results of orthodontic treatment. With age due to growth of soft tissues of the face, the profile of an individual becomes more convex. Gross facial imbalance can be caused by additional growth of the nose after the appliance removal. Extractions should be avoided in growing patients. These cases show favorable results with growth response (growth redirection). If further growth is unlikely to alter facial profile, extraction decision will be safer.

2. Treatment Modalities of Borderline Cases

Management of borderline skeletal malocclusions in growing individuals

Functional appliances

In skeletal class II cases where mandible is functionally retruded and patient is in adolescent growth (female 10-14 yrs and male 11.5 - 15.5 yrs) we can use functional appliances for correction of retrusion. Functional appliance should be used before the peak height velocity (PHV, females- 12 yrs and males- around 13 and half yrs of age) for best results. For use of functional appliance few other important points of consideration are good posterior facial height, low or normal anterior facial height, increased Jarabak ratio, average to low mandibular plane angle, normal IMPA. Pubertal spurt i.e. CVMI – III stage must be used. This approach might avoid extraction of teeth or surgery later after achieving adulthood. ³⁶ Skeletal class – II and class – III Cases can be treated with nonextraction if VTO is positive. Functional appliances like twin block and its modification can be used for favourable facial growth.

Orthopaedic appliances

Orthopaedic forces are interrupted & intermittent in nature—applied for about 10-12 hours a day. Tooth movement tendency is decreased since body restricts normal circulation for about 12-14 hrs when the appliance is not worn. But the total effect on periosteal sutures & maxillary growth centres is not lost, since the membranous bones have been under restrictive force for about 10-12 hrs. Heavy interrupted forces thus produce significant basal bone effect with minimum response of teeth to move. ³⁷

Clinical application of orthopedic forces

- In class I malocclusion: When there is arch length / tooth size discrepancy problem – patient is treated in Early Mixed Dentition by either serial extraction or orthopaedic expansion. Head – gears are used when maximum anchorage is needed to maintain the existing Arch Length.
- In class II malocclusion: Headgear is used for four main purposes 1. Anchorage control 2. Tooth movement 3. Orthopaedic changes 4. Controlling the cant of occlusal plane.
- Maxillary skeletal protrusion: Cervical (low pull) face bow is used in patients with decreased VD (Kloehn, Graber, Weislander) Occipital (high pull) face bow is used in patients with increased VD.
- Maxillary skeletal retrusion: They have increased lower facial height, a steep mandibular plane angle, retruded position of chin point. Can be treated by vertical pull chin cup which produces upward & forward movement of maxilla & counter clockwise rotation of the mandible.
- Maxillary dento alveolar protrusion: Flared upper incisors are retracted using a High–Pull HG or Straight pull combined with J–Hooks or a closing Arch supported by HG.
- Mandibular skeletal retrusion: Treated by functional jaw orthopedics which includes forward posturing of the mandible. Eg. FR2, Bionator.

- In Class III malocclusion: It may be due to maxillary deficiency or mandibular excess. In max. deficiency Reverse pull head gear or protraction head gear by Hickham, Face mask by Delaire, Sub-orbital protraction appliance: Developed by Grummons or Maxillary protraction bow appliance may be used.
- 2) Mild expansion in the mixed dentition which frequently exhibit lack of space for the upper laterals and in which the long range growth forecast is favorable.
 - 3) Class III - Expansion needed
 - 4) Class II cases
 - 5) Thumb sucking or Tongue thrusting cases
 - 6) Cleft palate conditions either unilateral or bilateral

Management of borderline dentoalveolar malocclusions in growing/ non-growing individuals

Proximal stripping

Black was amongst the pioneers who described natural slenderization in 1902. Ballard first described a technique to reduce the tooth material by reducing the enamel. Peck called this procedure as reproximation. Various techniques

- 1) Abrasive strips
- 2) Hand piece mounted reducing discs
- 3) Air-rotar stripping: first described by Sheridan It can be measured with commercially available gauges. A conservative guideline is to remove no more than .75mm of interproximal enamel between the anterior contact points and no more than 1mm from the posterior contact points.³⁸
- 4) Intensive Orthostrip system (GAC)³⁸: It involves the use of hand piece driven abrasive strips with different configuration and abrasive potential.

Molar Distalization³⁹

Indications: Straight profile, Normal and healthy temporomandibular joint, Correct mandible to maxillary relationship. Skeletally, Class I skeletal base, Normal / short lower facial height, Maxilla with normal transverse width, Brachycephalic growth pattern, Skeletal closed bite. Dentally, Class II molar relationship, Deep overbite, Permanent dentition, Maxillary first molar mesially inclined, Maxillary cuspids labially displaced, Loss of arch length due to premature loss of second deciduous molar.

Upper Molar Position: This indicates or contraindicates molar distalization.

Appliances used for distalization: Headgear, Atkinson Buccal Bar, Herbst Appliance, Jasper Jumper, Pendulum And Pendex Appliance, Mini Distalization Appliances, Distal Jet Appliances, Wilson's Distalizing Arch (Bimetric Distalizing Arch), Compressed Springs, Repelling Magnetic Appliance, K-Loops, Sliding Jig etc. while for upper molar Distalization. Lip Bumper, Modified Lingual Appliance, Distal Jet for Lower Molar can be used.

Maxillary expansion: Expansion can be divided into various arbitrary categories including orthodontic, passive, and orthopedic.

Slow expansion devices:

Active plates for arch expansion

A base plate with a jackscrew. useful when only a few millimeters of space are needed.

Quad Helix Appliance⁴⁰ : Indications:

- 1) All cross- bites in which the upper arch needs to be widened

Rapid maxillary expanders: RME is an appliance of choice for expansion of maxillary halves when maxillary bases are constricted. Common appliances⁴¹ are

- 1) Derirshweiler type
- 2) Hass type
- 3) Issacson type: uses a special loaded screw called a Minne expander
- 4) Bidermann type: requires a special screw either Hyrax (Dentaram 602-813) Leaone 620 or Unitex 440-160.

Jackscrew Turn Schedules⁴²: Zimring and Isaacson recommend:

- 1) Young growing patients two turns each day for the first 4 to 5 days, one turn each day for the remainder of RME treatment.
- 2) Adult (non growing) patient - because of increased skeletal resistance, two turns each day for the first 2 days, one turn each day for the next 5 to 7 days, and one turn every other day for the remainder of RME treatment.

Uprighting of posterior teeth⁴³

Tilted posterior teeth always occupy more space. Uprighting of molars can lead to an arch length gain of 1- 1.5 mm. fixed appliances are ideally used for the purpose. Space regainers or the various screw appliances are also used frequently. Passive uprighting : 4mm space can be gained by lip bumpers or Frankel in late mixed dentition by passive uprighting.

Derotation of posterior teeth⁴³

For a similar degree of rotation, the molars occupy more space as compared to premolars, whereas rotated anterior teeth occupy less space. Derotation can be best achieved using a couple (forces equal in magnitude but opposite in direction) on the lingual and buccal surfaces of the tooth.

Proclination of Anterior teeth⁴³ can be undertaken in cases where these teeth are retroclined or their proclination will not effect the soft tissue profile of the patient adversely or the stability of the result achieved. Any of the proclination springs ("Z" spring, mattress spring, etc.) or fixed appliances can be used for the purpose.

Utilization of leeway space

The leeway spacing in mixed dentition can be used for the correction of discrepancy. We can use lip bumper, lingual holding arch, Nance palatal bar, before the exfoliation of second deciduous molar.

Management of borderline skeletal malocclusions in non-growing individuals who require surgical intervention:

In borderline cases without severe skeletal discrepancies, orthodontic camouflage treatment may be an acceptable choice compared to orthognathic surgery⁴⁴. Before TADs

became available, distalization in the upper jaw had to rely on extra-oral traction using headgear in which patient compliance was detrimental to the success of the therapy.

Use of temporary anchorage devices

With the introduction of TADs, patient cooperation became less important with the added benefit of almost absolute anchorage.⁴⁵ Of all orthodontic implants, miniscrews have gained considerable importance due to less surgical procedure and easy installation.

Indications⁴⁶: Mini implants are used most beneficially where three dimensional stable anchorage is needed,

- 1) Where you cannot afford any movement of reactive units (maximum anchorage case)
- 2) Patient with several missing teeth making it difficult to engage posterior units
- 3) For difficult tooth movements, eg intrusion of anterior and posterior segments and distalisation
- 4) Where asymmetrical tooth movement is needed
- 5) To treat borderline cases with non extraction method
- 6) Doing extreme orthodontics when patient is not willing to undergo orthognathic surgery.

Post Treatment Stability

Lower incisor position should be decided with the position of maxilla. The tip of the lower incisor should not be more than 3 mm from APog line for the stability⁴⁷. It is also established that intercanine width decreases in post retention phase therefore cases treated with extraction of incisors in lower incisor crowding cases remain stable⁴⁸. Whether a case is treated with extraction or nonextraction approach the most important thing is that the denture should be able to withstand the natural forces unrestrained with the period of time.

3. Conclusion

In borderline cases there is no single diagnostic criteria on which we can rely. We have to see the remaining growth of the patient and other diagnostic factors like facial appearance, result of the treatment and stability. Further, borderline cases may also have absence of dental or craniofacial anomalies.

Dichotomy of extractions/non-extractions exists with these cases. Reproximation, expansion of arches, Molar distalization, derotation of posteriors, Proclination of anteriors and Uprighting of molars have been employed for management of borderline cases. Temporary Anchorage Devices / TADs revolutionized orthodontic treatment by decreasing the concern to anchorage, changing the extraction choices, bringing the most difficult tooth movements and providing better orthodontic treatment for some borderline orthognathic surgical patients.

Therefore; precise treatment planning is a must for borderline cases to provide best possible esthetics and stability of the results to the individual. All the treated cases require faithful wearing of retainers.

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