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Dimensions of the denture: Back to basics

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The three dimensions of the denture, height, width, and length, allow tooth movements in six directions. The limitation of the tooth movements that can be accomplished is the physical environment of bone, muscle, and soft tissue. By using clinical records of more than 200 cases, each dimension of the denture was analyzed as to lateral, anterior, posterior, and vertical protraction and contraction. A study of 40 successful treatments indicated that posttreatment adjustments reflected contraction of the dentition and that protraction would not be tolerated by the dental environment of patients with normal muscular balance. A total dentition space analysis system was devised to help differentiate proper treatment strategy for all the dimensions of the denture. The space analysis emphasized the point that orthodontics is a space management procedure, and the orthodontist must become skilled in determining the space available, as well as future space increase through growth and development. Finally, guidelines were suggested for space management of all the dimensions of the dentition. These guidelines were based on an anterior, a midarch, and a posterior space analysis so that the major areas of disharmony could be identified and proper space management decisions could be made. (Am J Orthod Dentofac Orthop 1994;106:535-42.)

The clinical practice of orthodontics has always been based on the various dimensions of the denture. There are three dimensions of the denture, height, width, and length. These dimensions allow the teeth to be moved in six directions, mesially, distally, laterally, lingually, intrusively, and extrusively. All these movements, which are easily accomplished with orthodontic appliances, are limited and restricted by the physical environment of bone, muscle, and soft tissue that exerts influence on the teeth and the jaws. Since the beginning of the orthodontic specialty, an effort has been made to determine the extreme limits of this environment. It seems that with each engineering change in appliance fabrication, our specialty must again challenge the physical limitations of the denture's environment.

The length of the denture has an anterior and a posterior limit. Tooth movement beyond these limits, though easily accomplished, leads to a multitude of problems.

Anterior expansion of the denture is characterized by a protrusion of the lips, a lack of balance and harmony of the lower face, and a lack of health of the bone and investing tissue. Unless the musculature is very weak, the muscular environment will reassert itself and cause a collapse or crowding of the teeth, a deepening of the bite, an increase in overjet, and finally a deterioration of the investing tissues.

Charles Tweed spent most of his orthodontic career investigating the anterior limits of the denture. He gave orthodontics many valuable and reliable guidelines about anterior tooth placement. His studies concluded that mandibular incisor position must be maintained or that these teeth must be contracted lingually so that they are positioned over basal bone and in harmony with the muscles of this region. Otherwise, either facial esthetics or denture stability or both would be in jeopardy. The use of Tweed's diagnostic facial triangle is a very simple and accurate means of determining the dimensions of the denture in the mandibular incisor area. Used properly, this simple analysis will constantly monitor one's treatment progress and prevent violation of the anterior limit of the denture. The following cephalometric tracings and facial photographs illustrate proper respect for the anterior limit of the denture. The case is a rather extreme bimaxillary protrusion. The pretreatment photographs of the face (Fig. 1) reflect imbalance and disharmony. The FMA of 30°, the FMIA of 49°, and the IMPA of 101° reflect the protrusion (Fig. 2). This is a typical anterior discrepancy case. The posttreatment tracing (Fig. 3) confirms that treatment was successful. The FMA flattened to 24°, the FMIA increased 17°, and the mandibular
incisor was uprighted 12° from 101° to 89°. The posttreatment facial profile (Fig. 4) exhibits nice soft tissue balance and distribution. The superimposition cephalometric tracing (Fig. 5) shows the bodily retraction and intrusion of the maxillary incisors and the lingual tipping of the mandibular incisors. The treatment of this case reflects respect for the anterior limit of the denture.

The orthodontist, while considering the anterior end of the denture, must put an equal amount of thought and consideration into the posterior end.

The bony environment of the mandibular molars effectively prohibits significant posterior expansion of the mandibular molar teeth. This is illustrated by Fig. 6, a cephalometric radiograph of a 12-year-old girl. Note the impacted mandibular second molars. The maxillary second molars are also unerupted due to space deficit. The case was started without premolar extraction. The mandibular second molars after 8 months of nonextraction treatment (Fig. 7) are hopelessly impacted and the maxillary molars, if they erupt, will erupt off the tuberosity. The patient’s cephalometric radiograph, as treatment is being completed after second premolars were removed (Fig. 8) shows the second molars in the mouth and in occlusion.

Because the maxilla does not have heavy bone support at the tuberosity, it seems to invite one to attempt to use orthodontic forces to move maxillary molars distally into “normal Class I” inclined plane
relationships. However, when a study is made of the anatomy of this area, one finds strong muscular pressure being exerted by the buccinator, the masseter, the temporalis, and the internal pterygoid muscles. This muscular environment limits posterior expansion. Class II malocclusions, if treated to Class I inclined plane relationships by distal movement of maxillary teeth either with intraoral elastics or extraoral headgear forces, or any combination of distal driving forces, when space does not exist, show certain characteristic symptoms. The symptoms are the maxillary second molars will, if banded, be driven distally off the tuberosity. If unbanded, these second molars will be driven both distally and buccally. The third molars will, in most cases, be deeply impacted because there is generally not enough tuberosity growth to accommodate these teeth in the arch. This illustration brings home the point that to create a posterior discrepancy in an attempt to correct an anterior discrep-
ancy is not sound reasoning. It is important to note that uprighting mesially inclined maxillary or mandibular molars that are in a forward position as a result of habits or the premature loss of deciduous teeth is not a form of posterior expansion. It is a proper treatment objective if the original malocclusion arch length, both anteriorly and posteriorly, is respected.

The second dimension of the denture is width. This is the dimension that is perhaps most easily monitored, and yet it is the dimension in which the greatest transgressions seem to be made in clinical orthodontics. Robert Strang did a great deal of work on denture stability and lateral expansion. He stated, “The mandibular cusp width, as measured across the arch from one canine to the other, is an accurate index of the muscular balance of the individual and dictates the limit of denture expansion in this area.” He further stated, “With very minor exception, the original mandibular malocclusion width must also be respected in the premolar and molar areas.” The recent studies reported in the literature by Little, et al. seem to confirm Strang’s hypothesis that mandibular canine width is inviolate.

In a further effort to define this dimension of the denture, the casts of 40 treated cases with pretreatment, posttreatment and recall records were measured. The measurements of mandibular canine width in these 40 cases revealed an average expansion of less than 0.4 mm from the start of treatment to the completion of treatment. The recall casts showed an equal amount of contraction (0.4 mm) (Table I). This study validated Strang’s conclusions that mandibular canine width should not be violated. A study of the measurements of the mandibular first molar width on these cases showed an average contraction of 0.5 mm between the start of treatment and completion of treatment and an additional 0.2 mm of contraction between treatment completion and recall (Table I). The maxillary molar width on these cases was also recorded. An average change of 0.2 mm of contraction from starting records to completion with an additional 0.3 mm of contraction from completion to recall was measured (Table I).

This study confirmed the belief that orthodontists must accept the original tooth position as the extreme width of the buccal segments in patients with normal muscular balance. It also suggested that the environment will tolerate some contraction in the buccal segments and that further contraction will occur after the cessation of treatment.

The third dimension of the denture that must be respected is the vertical dimension—height. Tooth movements that can be involved are intrusion and extrusion. The muscles of mastication limit this dimension of tooth movement. This muscular environment has, before orthodontic interference, established a functional balance of the vertical position of the posterior teeth. This balance allows a normal freeway space and efficient functioning of the temporomandibular joint, as well as a growth direction inherent to the person. Vertical
Table 1. Canine molar width

<table>
<thead>
<tr>
<th>Forty patients</th>
<th>Pretreatment</th>
<th>Posttreatment</th>
<th>Recall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mandibular canine width</td>
<td>25.8 mm</td>
<td>26.2 mm</td>
<td>25.8 mm</td>
</tr>
<tr>
<td>Mandibular molar width</td>
<td>45.2 mm</td>
<td>44.7 mm</td>
<td>44.3 mm</td>
</tr>
<tr>
<td>Maxillary molar width</td>
<td>51.1 mm</td>
<td>49.9 mm</td>
<td>49.6 mm</td>
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</table>

expansion of either the maxillary or mandibular posterior teeth causes many undesirable reactions. Included among these could be (1) mandibular rotation, (2) freeway space impingement, (3) maxillary reorientation to cranial base, and (4) an unstable orthodontic treatment result. A constantly stated orthodontic treatment objective is to use mechanical forces that act in harmony with normal downward and forward growth and development or to use forces that are directed to counteract undesirable vertical patterns. Extrusive forces that cause vertical expansion create a downward descent of the anterior part of the lower face. One millimeter of vertical expansion in the maxillary molar area results in a 1.3 mm descent in the maxillary incisor area. This reaction is not complimentary to facial balance and certainly does not enhance a facial pattern that needs horizontal development. Vertical control should be monitored with lateral head films during the course of treatment. The relative relationship of the palatal plane, the occlusal plane, and the mandibular plane when superimposed on head film tracings could be the best guide to control of vertical expansion. These three planes should remain parallel or flatten slightly posteriorly as treatment progresses.

Vertical expansion, like lateral expansion, seems to occur with posterior expansion. If maxillary molars are moved distally into Class I relationships when there is no space for this movement, there is a wedging open in the posterior part of the mouth. This wedging effect encourages a drop of anterior nasal spine and pogonion. These reactions result in the convex face which has been described as the "orthodontic look."

Anterior, posterior, lateral, and vertical expansion all result in instability of the treatment result. They adversely influence facial esthetics and functional efficiency, as well as the health of the teeth and their investing tissues. If these four types of expansion are to be avoided, what leeway does the clinician have to effect malocclusion corrections? It is possible, and many times advisable, to effect lingual contraction of the dental arches or segments of the arches. The lingual dental environment is apparently more adaptable, and any relapse from lingual contraction that occurs moves the denture into an area of greater space that allows adjustments to occur without blocking out, rotating or crowding the teeth. Another directional movement of the teeth that can be achieved is vertical intrusion. It is admittedly very difficult to intrude posterior teeth with orthodontic forces. However, maxillary anterior teeth can be efficiently intruded with proper force systems. To control the teeth and to achieve needed malocclusion correction, one should strive to use directional forces that place intrusive forces on the molars and the maxillary anterior teeth. These forces are so effectively counteracted by the dental environment that they allow one to achieve other needed adjustments in a mesial and distal direction within the arches themselves and at the same time maintain maximum control.

TOTAL DENTITION SPACE ANALYSIS

Since the original diagnosis and treatment plan must accept the dimensions of the denture presented in the original malocclusion when musculature is normal (i.e., Class I), a total dentition space analysis allows the clinician to develop a differential diagnosis that respects the dimensions of the denture concept during the treatment planning process. Available space can neither be created nor destroyed by tooth movement. Orthodontics therefore is a space management procedure. It is an attempt to balance tooth material most advantageously with present and future space available. All 32 teeth must be considered, as well as the anterior, posterior, vertical, and lateral dimension of the denture.

Total dentition space analysis (Fig. 9) is divided into three parts: (1) anterior, (2) midarch, and (3) posterior. This division is made for two reasons: (1) simplicity in identifying the area of space deficit or
**TOTAL DENTITION SPACE ANALYSIS**

<table>
<thead>
<tr>
<th>A. Anterior Denture Area</th>
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<tbody>
<tr>
<td>a) Teeth width</td>
<td>3 2 1 1 2 3</td>
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<tr>
<td>b) Available space</td>
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<tr>
<td>c) Tooth arch disc</td>
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<tr>
<td>d) Headfilm Correction</td>
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<tr>
<td>e) Soft Tissue Modification</td>
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<tr>
<td></td>
<td>Deficit____ Surplus____</td>
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<thead>
<tr>
<th>B. Mid-Arch Denture Area</th>
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<tbody>
<tr>
<td>a) Teeth width</td>
<td>6 5 4 5 6</td>
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<td>b) Available space</td>
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<tr>
<td>c) Tooth arch disc</td>
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<td>d) Curve of spec</td>
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<th>C. Posterior Denture Area</th>
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<tbody>
<tr>
<td>a) Teeth width</td>
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<tr>
<td>b) Available space</td>
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<td>c) Tooth arch disc</td>
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<td>d) Estimated increase</td>
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<td>Deficit____ Surplus____</td>
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**DENTURE TOTAL**

**Headfilm Correction**

- FMA 21° - 29° the FMIA should be 68°
- FMA 30° or greater the FMIA should be 65°
- FMA 20° or less the IMPA should not exceed 92°
- $B \times$ the FMIA difference = correction

**Increase in Posterior Denture Area**

- 2 mm/yr for girls until age 14.
- 2 mm/yr for boys until age 16.

**Fig. 9. Total dentition space analysis.**

space surplus, and (2) a more accurate differential diagnosis.

**ANTERIOR SPACE ANALYSIS**

Anterior space analysis includes the measurement in millimeters of the space available in the mandibular arch from canine to canine and a measurement of the six anterior teeth mesiodistally. The difference is referred to as a surplus or a deficit. Tweed’s diagnostic facial triangle is also used to further analyze this area. A head film discrepancy, based on the amount of mandibular incisor uprighting that is needed to restore facial balance, is added to the anterior space measurement. The total, if a deficit, is referred to as anterior discrepancy. Anterior discrepancies are most easily resolved, if they are the overriding consideration of the malocclusion, by removal of the first premolar teeth and by using the resulting space to move the canines distally to obtain the space to upright and align the incisors.

**MIDARCH ANALYSIS**

The midarch area includes the mandibular first molars and the second and first premolars. Careful analysis of this area can show mesially inclined first molars, rotations, spaces, deep curves of Spee, crossbites, missing teeth, habit abnormality,
blocked out teeth, and occlusal disharmonies. This is an extremely important area of the denture. Being in the center of the arch, this area allows the easiest and most direct method of space management for malocclusion correction when it can be so used. Crowding, deep curves of Spee, end-on, and Class II occlusions not accompanied by anterior discrepancy, all indicate a need for second premolar extraction in the lower arch. Careful measurement of the space from the distal of the canine to the distal of the first molar should be recorded as available midarch space. An equally accurate measurement of the mesiodistal width of the first premolar, the second premolar, and the first molar must also be recorded. To this is added the space required to level the curve of Spee. From these measurements one can determine the space deficit or surplus in this area.

Many diagnosticians have suggested that they extract second premolar teeth to eliminate facial retrusion. This is faulty reasoning. These cases have, as a rule, very little anterior discrepancy, and the second premolars are removed because their space is most advantageously used for the midarch problems that these cases usually demonstrate. The midarch space analysis is critical in proper differential diagnosis.

POSTERIOR SPACE ANALYSIS

The posterior denture area has great importance, and has at times been ignored or mistreated by our specialty. The required space in the posterior space analysis is the mesiodistal width of the second molars and the third molars in the mandibular arch. The available space is more difficult to ascertain on the immature patient. It is a measurement in millimeters of the space distal to the mandibular first molars along the occlusal plane to the anterior border of the ramus, plus an estimate of posterior arch length increase, based on both age and sex.

There are certain variables that must be considered in estimating the increase in posterior space available. These variables are as follows:

1. Rate of mesioocclusal migration of the mandibular first molar.
2. Rate of resorption of the anterior border of the ramus.
3. Time of cessation of molar migration.
4. Time of cessation of ramus resorption.
5. Sex.
6. Age.

A review and study of the literature reveals that a consensus of researchers suggests 3 mm of increase in the posterior denture area occurs per year until age 14 years for girls and age 16 years for boys. This is a 1.5 mm increase on each side per year after the full eruption of the first molars. In the mature patient, girls beyond 15 years and boys beyond 16 years, one can measure from the distal of the first molar to the anterior border of the ramus at the occlusal plane and have an accurate determination of the space available in the posterior area. It is of extreme importance to know whether there is a surplus or deficit of space in this area during diagnosis and treatment planning. It is imprudent to create a posterior discrepancy while making adjustments in other areas—the midarch, or in the anterior area. It is equally imprudent not to use a posterior space surplus to help alleviate midarch and anterior deficits. The most easily recognizable symptom of a posterior deficit on the young patient is the late eruption of the second molar. If space is not available for this tooth by the age of its normal eruption, then one can pretty well ascertain that there is a posterior space problem. A good lateral jaw radiograph can immediately confirm the clinical observation by using the above-mentioned guidelines.

In summary, a total space analysis that analyzes the anterior, midarch, and posterior denture areas is a valuable diagnostic tool. It enables the orthodontic specialist to treat within the dimensions of the denture in the case with normal muscular balance. A total dentition space analysis, used within the dimensions of the denture framework, enables the orthodontist to make correct differential diagnostic decisions.

Diagnosis, by definition, is both subjective and objective. Webster defines diagnosis as a “determination of a disease from symptoms, data, or tests and the decisions and judgments made prior to treatment.” Thus the determination made in regard to whether, when, and which teeth need to be eliminated for proper space management is a differential diagnostic process. When diagnostic guidelines or decisions are suggested, they can appropriately be called “one man’s opinion.” The following diagnostic space management guidelines are suggested for use and should not be considered as rules. These space management suggestions are based on space analysis only. Any complete diagnostic scheme has to consider the facial pattern and the skeletal pattern.
INTRODUCTION TO DEFICITS AND DECISIONS

Space management guidance

<table>
<thead>
<tr>
<th>Space Management</th>
<th>Nonextraction</th>
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<tr>
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<td>16 mm and above.</td>
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<td>Extract:</td>
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</tbody>
</table>

**A. Anterior surplus or deficit: + to −2 mm**

- 3 to 5 mm without crowding. Extract: 8 | 8
- 3 to 5 mm with crowding. Extract: 5 | 5
- 5 to 7 mm with less than 3 mm anterior crowding. Extract: 4 | 4
- 5 to 7 mm with more than 3 mm anterior crowding. Extract: 4 | 4
- 7 to 15 mm anterior deficit. Extract: 4 | 4
- 16 mm and above. Extract: x4 | x4

**B. Midarch surplus or deficit: An anterior deficit or surplus overrides a midarch deficit so the first determination is a decision on the anterior deficit.**

- + to 3 mm
  - 3 to 5 mm without crowding. Extract: 8 | 8
  - 3 to 5 mm with Class II molar. Extract: 8 | 8
  - 5 to 7 mm with upper anterior protrusion. Extract: 5 | 5
  - 5 to 7 mm. Extract: 5 | 5
  - 8 to 15 mm. Extract: x4 | x4
    - x5 | x5
  - Over 15 mm. Extract: x4 | x4
    - x5 | x5

*(Use X for all molars: first, second, and third.)*

**C. Posterior surplus or deficit: The space analysis in this area is of great importance, although in corrective procedures, anterior and midarch deficits are overriding. The posterior space must be carefully measured and protected. No orthodontic treatment is complete until all decisions and treatment procedures are completed in this area.**

- + to −5 mm with good position of the third molars. Await full development of the third molars. Extract: 8 | 8
- + to −5 mm with poor position of third molars. Extract: 8 | 8

Note: Wait for maxillary third molars until age 16 years. Have the mandibular third molars removed immediately if other treatment is necessary.

5 to 15 mm. Extract: 8 | 8

(Determine the timing of these third molar extractions in relationship to symptoms and other treatment that is necessary.)

Consistent, quality orthodontic treatment results are based on fundamental concepts. The concept of dimensions of the denture is predicated on the conviction that the teeth and their supporting structures should be in a state of maximum environmental harmony (dynamic equilibrium). Total dentition space analysis, based on the dimension of the denture concept, is a valuable tool that can help the orthodontic specialist produce a consistently high quality result that meets the needs and expectations of the patient.

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