Differential Diagnosis with Total Space Analysis

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In a continuing critical, but objective analysis of the Charles H. Tweed Foundation's teaching program, which has now proudly passed its 30th birthday, it has enjoyed a great deal of popularity. The 600 Tweed Foundation members, our international reputation, and the overall prestige of the program attests to its success. Dr. Tweed started our program and was mainly responsible for 24 years of achievement. I have also been involved in the course for 24 years and between us we have welcomed over 2,000 students to Tucson. I can also report to you that our April 1977 class was fully subscribed as well as the October 1977 course. The April 1978 course is now complete. The present popularity is the greatest in history. I take great pride in these accomplishments, but I am not satisfied. There is a tremendous amount of work to be done to maintain our momentum and improve the quality of the teaching program. The next 10 years should be more challenging than ever.

It is with these thoughts in mind that I am continually analyzing our course content, and advising with the assistant course director and some 50 staff members, to effect orderly and progressive improvement. One area that I feel is especially important is that of diagnosis. For many years the Tweed Foundation has emphasized advanced technical training in the edgewise appliance. This should continue but we must integrate into the program a more comprehensive and sophisticated diagnostic philosophy. This includes using all of the present day knowledge of the denture and its surrounding environment. Students need more than a general diagnostic philosophy. They must be given specific guidelines for differential diagnosis.

This paper will discuss one element of diagnosis that is critical as one develops differentiation in diagnosis and treatment planning. This area I refer to as "Total Space Analysis".

Other space analyses I have studied were concerned with the space available for the anterior teeth. Dr. Tweed spent most of his orthodontic endeavors defining the anterior limits of the denture, but our more recent clinical research indicates that we must consider the entire denture. There is both an anterior and a posterior limit to the denture. Available space can neither be created nor destroyed by tooth movement. Orthodontics is a space manage procedure and is an attempt to balance tooth material most advantageously with the present and future space available. All thirty-two teeth must be considered as well as the anterior and posterior limits of the denture.

Total space analysis is divided into three parts: 1) Anterior, 2) Mid-arch, 3) Posterior. This division is made for two reasons: for simplicity in identifying the area of space deficit or space surplus, and for more accurate differential diagnosis.

ANTERIOR SPACE ANALYSIS

Anterior analysis includes the measurement in millimeters of the space available in the lower arch from cuspid to cuspid and a measurement of the six anterior teeth mesiodistally. The difference is referred to as a surplus or deficit. The diagnostic facial triangle is also used to further analyze this area. The headfilm discrepancy is added to the anterior space measurement and the total, if a deficit, is referred to as anterior discrepancy. These are most easily resolved, if they are the overriding consideration of the malocclusion, by removal of the first bicuspid teeth and utilizing the resulting space to move the cuspids distally and to upright and align the incisors.

MID-ARCH ANALYSIS

The mid-arch has been partially studied with the anterior region, however, it should include the mandibular first molars and the second and first bicuspids. Careful analysis of this area can show mesially inclined first molars, rotations, spaces, deep curves of Spee, cross bites, missing teeth, habit abnormality, blocked out teeth, and occlusal disharmonies. This is an extremely important area of the denture and I have given it an identity, "the mid-arch area". Being in the center of the arch it allows the easiest and most direct method of space management for malocclusion correction when it can be so utilized. Crowding, deep curves of Spee, end-on and Class II occlusions not accompanied by anterior discrepancy all indicate a need for second bicuspid extraction in the lower arch. Careful measurement of the space from the distal of the cuspid to the distal of the first molar should be recorded as available mid-arch space. An equally accurate measurement of the mesio-distal width of the first bicuspid, the second bicuspid, 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 bicuspid teeth to eliminate facial retrusion. This is faulty reasoning. These cases have, as a rule, very little anterior discrepancy and the second bicuspids are removed because their space is most advantageously utilized for mid-arch problems that these cases usually demonstrate. The mid-arch space analysis is critical in proper differential diagnosis.

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POSTERIOR SPACE ANALYSIS

The posterior area has great importance and has generally been ignored or mistreated by our specialty. In the future it will demand a great deal of our attention and one must develop skill in posterior space analysis. In the past we have been guilty of collecting our orthodontic fee and leaving the second molars in extreme malocclusion ranging from trauma to impaction and being even more negligent of the third molars. Before any measurement of posterior space can be made, one must understand that there is a posterior end to the denture. It is absolutely essential to realize this. By studying a series of patients we have determined that there are no healthy functioning teeth posterior to the anterior border of the ramus. Regardless of age, this appears to be the limit posteriorly.

The required space in 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 additional 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 available space. They are:

1. Rate of mesio-occlusal migration of the lower 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.

Considering all of the variables mentioned above I have, with Dr. James J. Cross of Ardmore, Oklahoma, studied a number of cases from our practices and have found that our cases show about 1 mm. of increase each year on each side until age 15 on girls and the same increase up to age 17 on boys. This clinical study thus determined that about 2 mm. per year could be included as increased available space in the posterior space analysis. A review and study of the literature revealed that a consensus indicated a more generous estimate of increase. The literature studied suggested 3 mm. of increase occurred per year until age 14 for girls and age 16 for boys. This would be 1½ mm. of increase on each side per year after the full eruption of the first molars. Generally one should use this guideline on immature patients after the age of 8 years. In the mature patients, girls beyond 15 years and boys beyond 17 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 in diagnosis and treatment planning to know whether there is a surplus or deficit of space in this area. Many of us are guilty of creating severe posterior discrepancies while making adjustments in other areas in the mid-arch and anterior regions, and many of us are also guilty of not utilizing a posterior space surplus to help alleviate mid-arch and anterior deficits. All of us have been guilty of not routinely making a total space analysis of the anterior, mid-arch, and posterior areas in our diagnostic endeavors.

In a slide discussion on this subject I have shown a number of cases from our practices that shows several clinical symptoms of posterior discrepancies. The most common, easily recognized, symptom on the young patient is the delayed eruption of the second molar. If space is not available for this tooth by the age of normal eruption, one can be pretty certain there is a posterior space problem. A good lateral jaw x-ray can immediately confirm the clinical observation by utilizing the above mentioned guidelines and computing a posterior space analysis. Some patients may have a surplus in one area and a distinct discrepancy in another area. These slides emphasized the need for careful space management if good quality, contemporary orthodontics is to be achieved.

To analyze total dentition space data, we use a simple form as follows:

TOTAL DENTITION SPACE ANALYSIS

A. Anterior denture area.
   1. Required space
      a. Teeth width.
      b. Head film correction.
      c. Soft tissue modification.
   2. Available space:
      Anterior deficit or surplus.

B. Mid-arch denture area.
   1. Required space.
      a. Teeth width.
      b. Curve of Spee correction.
   2. Available space:
      Mid-arch deficit or surplus.

C. Posterior denture area.
   1. Required space: teeth width.
   2. Available space.
      a. Presently available.
      b. Estimated increase.
      Posterior deficit or surplus.
      Denture total deficit or surplus.

The denture space analysis is more accurate after the eruption of the permanent dentition. However, an estimation can be made after the eruption of the 1st permanent molars and the four incisors by using accurate intra-oral x-rays.

To make the analysis one would proceed as follows:

A. Anterior denture area.
   1. Required space.
      a. Teeth width. Measure carefully the mesial-distal widths in millimeters of the central incisors, the lateral incisors, and the cuspids. This will be approximately 36 mm. in most dentitions.

b. Head film correction. Using the Tweed formula of:
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°. Determine the head film correction necessary to upright the anterior teeth over basal bone and to compensate for the angularity of the FM angle.

c. Soft tissue modification. This factor is used when the Z angle is not correlated with the FMIA. The Z angle should be 78° plus or minus 3° when the FMIA is 68° and proportional when the FMIA varies. If it is not, there is a disproportion in the thickness of either the total chin or the upper lip and a further compensation in anterior teeth positioning is necessary to achieve proper lower facial balance. The upper lip thickness should be slightly less than the total chin thickness for normal soft tissue distribution. The procedure to use in determining a millimeter value for this factor is:
1. Determine head film correction in degrees.
2. Add to present Z angle.
3. Subtract from 78°.
4. Multiply by .8 to obtain soft tissue modification in millimeters.

NOTE: This guideline is accurate only if there is no overjet. If overjet is present, it should be calculated by measuring in millimeters and converting to degrees by multiplying by 2.5 and adding this degree sum to the present Z angle value along with the head film correction before subtracting from 78°.

2. Available anterior space is the distance from the distal surface of the cuspid on the right to the distal surface of the cuspid on the left around the circumference of the arch in the anterior area.

B. Mid-arch denture area.

1. Required space.
   a. Teeth width. Measure the actual mesial-distal diameter of the mandibular first bicuspids, the second bicuspids, and the first molars.
   b. Curve of Spee correction. This is the amount of space in millimeters needed to level the curve of Spee. A formula can be used.
      1. Predicted arch length increase = 0.51 + 0.488 x. This formula is used when the deviation of the mandibular tooth on the right and left sides furthest from a flat occlusal plane is measured in millimeters, added, and the sum substituted for x. Another more practical method is to add in millimeters the height of the curve of Spee at its greatest curvature on both sides and divide by two.[1] The arch length increase is a space deficit and is added to the teeth width to get an accurate mid-arch space requirement.
      2. Available mid-arch space is the distance from the distal of the lower cuspid to the distal of the first molar on each side in millimeters and adding the two sums together.

C. Posterior denture area.

1. Required space. This measurement is the actual measured width mesio-distally in millimeters of the mandibular second molar and the third molar, if erupted. If unerupted, the image of these teeth is carefully measured in millimeters on a good intra-oral x-ray.
2. Available space.
   a. Presently available. Measure the distance in millimeters from the distal of the lower first molar to the anterior border of the ramus on the occlusal plane. The best record is a 5''x7'' lateral jaw x-ray. However, a good lateral head film can be used.
   b. Estimated increase. Take the age and sex and use the formula previously mentioned.

The available space in each of the three areas of the denture is subtracted from the required space and the resulting sum is either a total space surplus or deficit. This figure, as well as the denture location of the surplus or deficit, is critical in differential diagnosis.

Another critical factor in space management of the denture is the presence or absence of a Class II occlusal relationship. If a Class II condition is present and a space surplus exists in the mandibular arch this surplus can be utilized in the mid-arch region for Class II correction. Correction of the Class II by space management in the mandibular arch does not create a space surplus or deficit but the least complicating correction of a Class II malocclusion is by mandibular space management. Other corrections will require distal maxillary molar adjustments which necessarily create maxillary posterior deficits.

The analysis of the total denture space allows guidelines of diagnosis and treatment that assure the maximum end result.

Some subjective clinical judgment is still necessary and experience indicates that certain areas of deficits take precedence over others. I would suggest when more than one denture region shows a deficit or discrepancy, the anterior area overrides all others. The mid-arch would follow and the posterior area would be the final consideration. However, complete orthodontics requires that all areas of space deficit must be eliminated; otherwise, function, stability, health, and esthetics will be jeopardized.

As suggested earlier, orthodontics is primarily a space management problem that can only be successfully solved with a sophisticated differential diagnosis. Careful analysis of the anterior, mid-arch, and posterior areas of the denture will prevent careless errors in treatment planning. Total space analysis coupled with a skeletal and facial analysis gives our specialty much greater versatility and the opportunity to broaden our treatment goals and concepts. I truly believe there is no limit to our ability to correct malocclusions. Our limitation is our ignorance in identifying our problems. This is our challenge.

1. Leveling the Curve of Spee: Its effect on mandibular arch length. University of Tennessee Master Thesis Doyle W. Baldridge

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