SPACE ANALYSIS

Space analysis is a process that allows an estimation of the space required in each arch to fulfil the treatment aims. It helps to determine whether the treatment aims are feasible, and assists with the planning of treatment mechanics and anchorage control. Space planning is carried out in 2 phases:

1- to determine the space required for relief of crowding, overjet correction and creating space for any planned prostheses.

2- calculates the amount of space that will be created during treatment by molar distalization, arch expansion, inter-proximal stripping …etc.

Before undertaking a space analysis, the aims of the treatment should be determined as this will affect the amount of space required or created.

Space analysis can act only as a guide, as many aspects of orthodontics cannot be accurately predicted, such as growth, the individual patient's biological response and patient compliance.

MIXED DENTITION ANALYSIS:

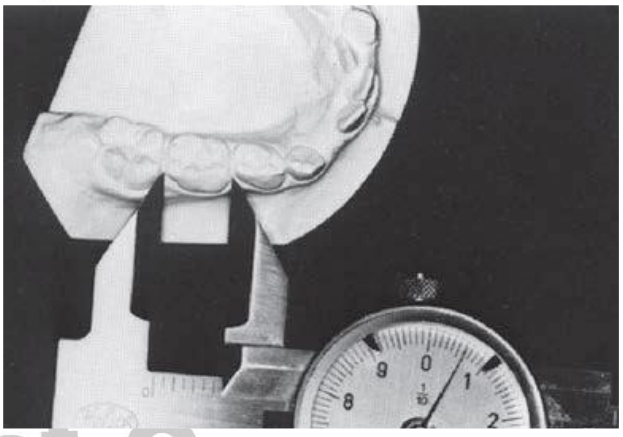
The purpose of a mixed dentition analysis is to evaluate the amount of space available in the arch for succeeding permanent teeth and necessary occlusal adjustments. The mesiodistal width of unerupted canine and premolars is calculated either from radiographs or predicted from the sizes of permanent teeth already erupted in the mouth:

1) Measurement from radiographs:

The widths of the unerupted canine and premolars is estimated using proportionate measurement from radiographs, which takes into account any magnification. The width of the unerupted tooth is measured directly from radiograph and the width of a deciduous molar is measured from the radiograph and from the dental cast and the following equation is used:

$$\frac{\boldsymbol{Unerupted\ tooth\ true\ width}}{Unerupted\ tooth\ radiographic\ width} = \frac{Deciduous\ molar\ true\ width}{Deciduous\ molar\ radiographic\ width}$$





2) Prediction tables or equation:

They are based on the direct measurement of the mesiodistal width of already erupted permanent teeth especially mandibular incisors to estimate the size of unerupted canine and premolars. The mandibular incisors were chosen since they erupt into the mouth early in the mixed dentition. The maxillary incisors are not used since they show a lot of variability in size.



The most commonly used methods are Moyer's Mixed Dentition Analysis and Tanaka and Johnson Analysis.

Moyers Mixed Dentition Analysis: The greatest mesiodistal width of each of the four mandibular incisors is measured from a cast and summed up. Then the combined widths of the unerupted canine and premolars are predicted by use of probability charts with 75% probability level.

	19.5	20.0	20.5	21.0	21.5	22.0	22.5	23.0	23.5	24.0
Max 75%	20.6	20.9	21.2	21.5	21.8	22.0	22.3	22.6	22.9	23.1
Man 75%	20.1	20.4	20.7	21.0	21.3	21.6	21.9	22.2	22.5	22.8

Tanaka and Johnson Analysis: They simplified Moyers table into a formula to predict the combined widths of the unerupted permanent canine and premolars (in one quadrant):

$$Upper\ canine\ \&\ premolars\ widths = \frac{width\ of\ four\ lower\ incisors}{2} + 11mm$$

$$Lower\ canine\ \&\ premolars\ widths = \frac{width\ of\ four\ lower\ incisors}{2} + 10.5mm$$

Remember that the width of the lower incisors is used to predict upper canine and premolars widths too.

Procedure of Mixed Dentition Space Analysis:

1. Measure the greatest mesiodistal width of each of the four mandibular incisors and determine the amount of space needed for their alignment.
2. Measure the distance from the mesial surface of the first permanent molar to the distal surface of the lateral incisor. Subtract the space needed for incisor alignment, any necessary molar adjustment and overjet correction to get the actual space available for the canine and two premolars. Repeat this process for both sides of the arch.
3. Predict the combined widths of the canine and premolars by the use of a probability chart or equation.
4. Finally, compare the space available with the predicted canine and premolars widths to estimate space need.

This will help decide on the use of space regainers or space maintainers.

a) Space need of 2mm per quadrant can be treated by lingual or palatal arch to preserve Leeway space giving room for eruption of the permanent premolars and canines and proper alignment of incisors.

b) Space need of 3mm per quadrant should be referred to the orthodontist to plan for space creation during the mixed dentition or later during comprehensive orthodontic treatment.

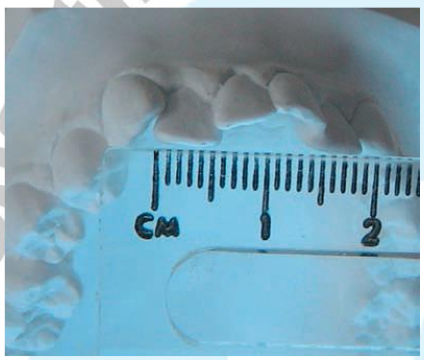
PERMANENT DENTITION ANALYSIS:

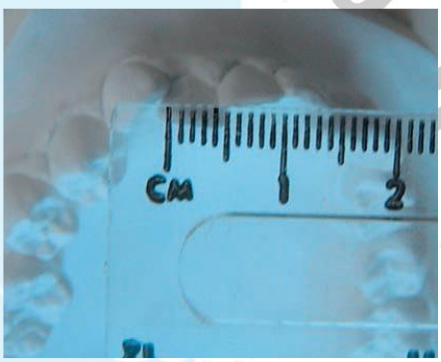
The aim of space analysis is to determine the space and anchorage requirements for orthodontic treatment.

Commonly Used Methods

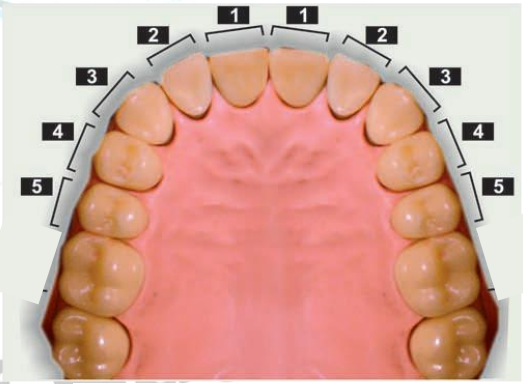
1- Visualization is the most commonly used method but is inaccurate in quantifying crowding.

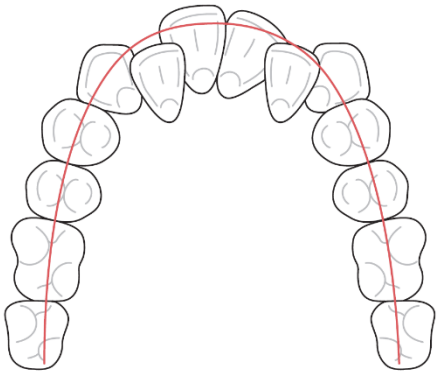
2- The amount of crowding can be calculated by measuring the mesiodistal width of any misaligned tooth in relation to the available space in the arch. This process is repeated for all the misaligned teeth in the arch to give the total extent of crowding.

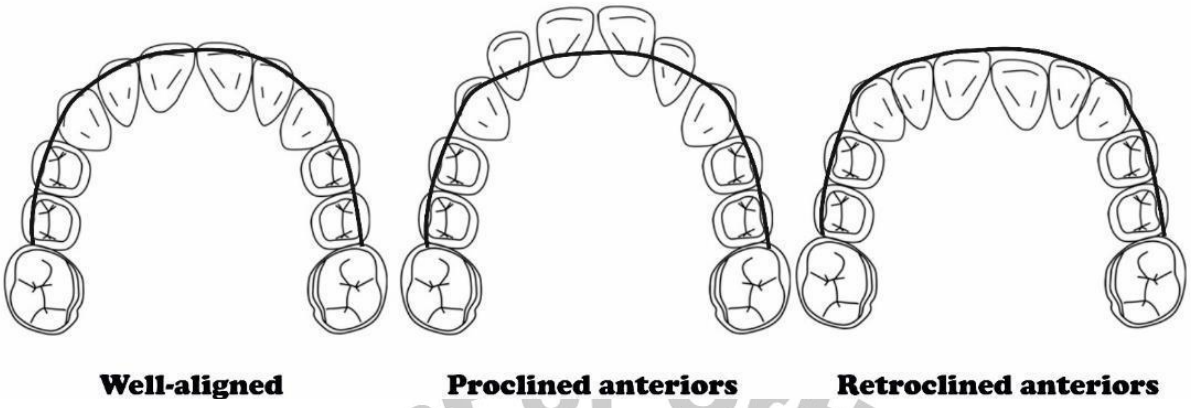




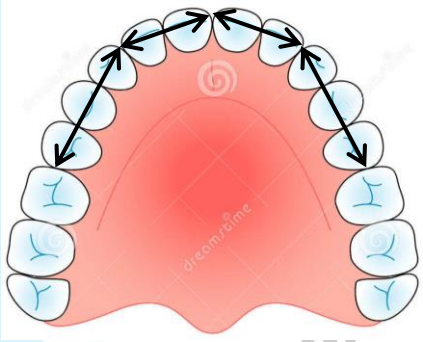
3- Arch perimeter/ Carey's Analysis: the mesiodistal widths of the incisors, canines and premolars are measured by a divider and the sum represents the space needed. A soft brass wire is passed from the mesial surface of the first molar to the contra-lateral side. The wire passes along the buccal cusps of premolars and incisal edges of the anteriors. In crowded arches, the wire should be pass according to the arch form that reflects the majority of the teeth. The wire should pass along the cingula of anterior teeth if they are proclined and along their labial surfaces if they are retroclined. The wire is then straightened to measure the space available. The difference is the space need or excess.



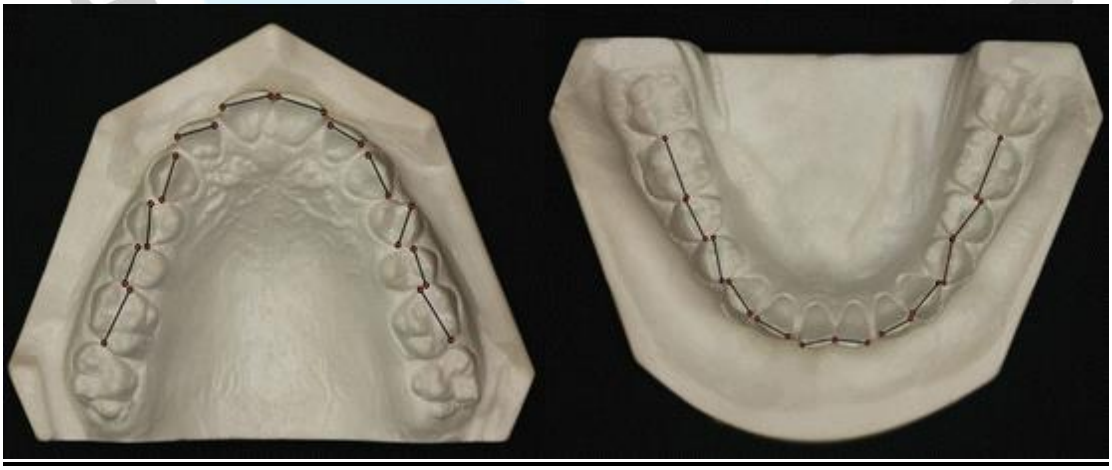




4- Segmental arch analysis: The same as Carey's Analysis but done in three segments; from the mesial of the first molars to the mesial of the canines for the distal segments and between the mesial of the canines for the anterior segment.



5- Digital 3D scanning: Many software programs are equipped with a facility to plot contact points in order to identify the arch form, as well as a 'virtual ruler' that can measure mesiodistal tooth widths.



Malocclusion Features to Consider in Space Analysis:

1) Crowding and spacing:

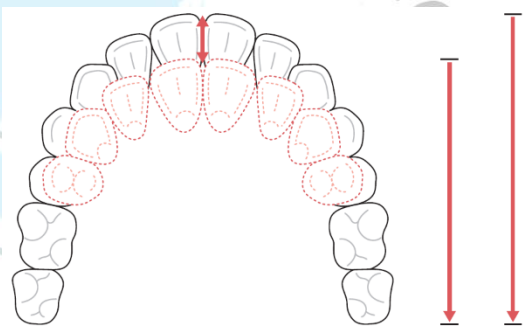
Crowding and spacing should be measured mesial to the first permanent molars in relationship to the archform that fits the majority of teeth. The mesiodistal width of the malaligned teeth is measured followed by the available space within the archform. Crowding can be quantified as mild (<4 mm), moderate (4–8 mm) or severe (≥8 mm).

If the second deciduous molars are retained, approximately 1 mm of space per quadrant will be available following exfoliation and eruption of second premolars in the upper arch and 2 mm in each quadrant in the lower arch.

2) Incisor anteroposterior movement

With few exceptions, the lower incisor anteroposterior (AP) position should be accepted to maximize stability. In Class II malocclusions, the upper incisors must be retracted for overjet reduction.

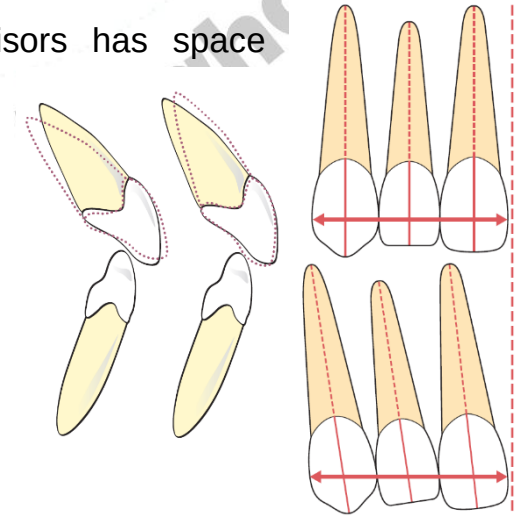
Conversely, in Class III malocclusions the upper incisors may be advanced and the lowers retracted to correct a reverse overjet. For every 1 mm all four incisors are retracted, 2 mm of space (1 mm per quadrant) is required. Conversely, for every 1 mm all four incisors are advanced, 2 mm of space will be created.



3) Correction of upper incisor angulation and inclination

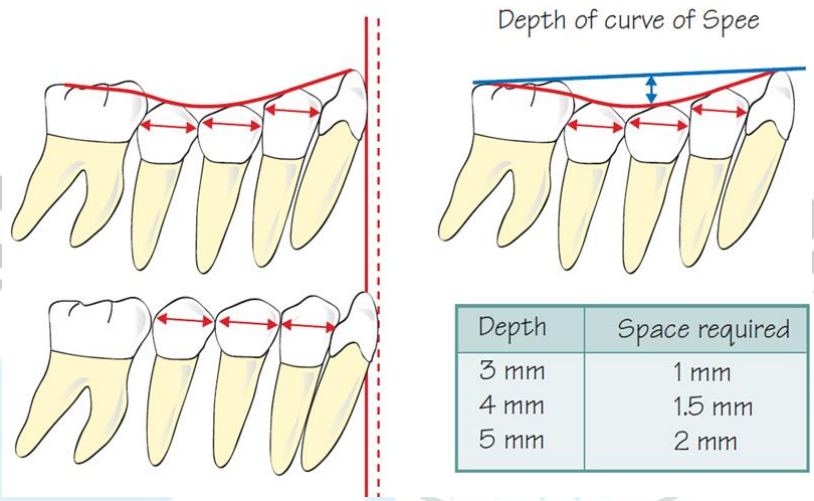
Changing the inclination (torque) of incisors has space implications. When the upper incisors are proclined, the overjet increases and space is required to normalise this increase. When proclined incisors are retroclined, every 5° of retroclination will reduce the overjet by 0.5mm and requires 1mm of space.

The space requirement to correct incisor angulation (mesiodistal tip) is usually minimal.



4) Levelling the curve of Spee

Where there is no occlusal stop the lower incisors may over-erupt resulting in an occlusal curve which runs from the molars to the incisors (Curve of Spee). Levelling an increased curve of Spee requires 1 to 2mm of space depending on the depth of the curve, which is measured from the premolar cusps to a flat plane joining the distal cusps of first permanent molars and incisors. Flattening deep curves of Spee increasing arch length and labially proclines the incisor teeth.



Depth	Space required
3 mm	1 mm
4 mm	1.5 mm
5 mm	2 mm

5) Arch contraction and expansion

Upper arch lateral expansion is undertaken for posterior crossbite correction and is useful in providing space for the relief of crowding and/or overjet reduction. Every 1 mm of lateral expansion creates approximately 0.5 mm of space within the arch. While, arch contraction requires space.

6) Tooth reshaping or replacement

Mesiodistal enlargement of microdont teeth and replacement of missing teeth require space. Also, extremely large teeth need to be stripped to normal size. This needs to be taken into account when determining total arch space requirements.

Once all of the above factors have been considered, it is possible to calculate the space required within each arch.

Calculating Space Requirement:

A patient has:

- 6mm overjet
- 3mm curve of Spee in the lower arch
- 2mm upper arch crowding
- 2mm lower arch spacing
- requires upper arch expansion of 4mm
- requires 2mm stripping of his large upper central incisors

Calculate the space requirement.

- The overjet is increased by 4mm (6 – 2 = 4mm). To reduce overjet to normal 8mm of space is required (4 x 2 = 8mm, 4mm of each side).
- Leveling a 3mm deep curve of Spee requires 1mm of space.
- 4mm of expansion creates 2mm of space within the upper arch

	Upper arch	Lower arch
Crowding / spacing	-2 mm	+2 mm
Incisor AP movement	-8 mm	
Incisor inclination		
Levelling the curve of Spee		-1 mm
Arch contraction / expansion	+2 mm	
Tooth enlargement / replacement	+2 mm	
Total	-6 mm	+1 mm

A positive score shows space gain; a negative score shows space requirement.

The patient has 6mm space need in the upper arch and 1mm extra space in the lower arch.

BOLTON RATIOS AND TOOTH-SIZE DISCREPANCY

A tooth-size discrepancy is a disproportion amongst the sizes of individual teeth and is a reason why it can be impossible to achieve an ideal occlusion orthodontically (interdigitation, overjet, overbite).

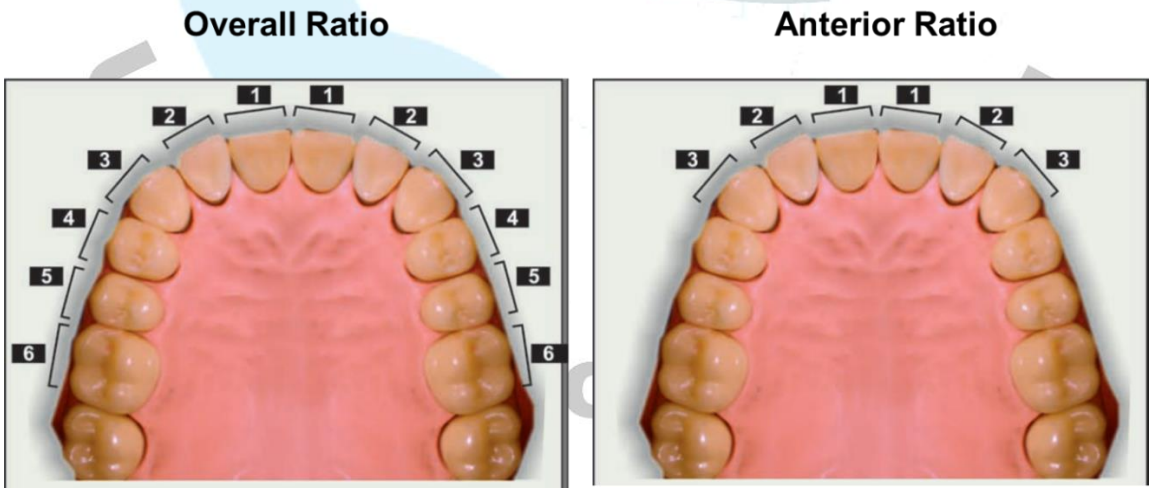
Common examples of a Bolton discrepancy include the presence of small maxillary lateral incisors and class III malocclusions, where there is a tendency towards a relative mandibular tooth excess.

Bolton evaluated the ideal ratio of tooth material between the maxillary and mandibular arch on 55 cases with excellent occlusions. The maxillary tooth material should approximate desirable ratios, as compared to the mandibular tooth material. Bolton's analysis helps to determine the disproportion between the size of the maxillary and mandibular teeth.

There are two ratios for ideal occlusion: the first for the ratio of tooth widths associated with the anterior teeth (anterior ratio) and the second for the whole arch from the first molars forwards (overall ratio).

$$\text{Overall ratio} = \frac{\text{sum of the mesiodistal widths of the mandibular 12 teeth}}{\text{sum of the mesiodistal widths of the maxillary 12 teeth}} \times 100$$

$$\text{Anterior ratio} = \frac{\text{sum of the mesiodistal widths of the mandibular anterior 6 teeth}}{\text{sum of the mesiodistal widths of the maxillary anterior 6 teeth}} \times 100$$



Overall ratio: The sum of the mesiodistal widths of the 12 mandibular teeth should be 91.3% the mesiodistal widths of the 12 maxillary teeth. If the overall ratio is greater than 91.3%, then the mandibular tooth material is excessive; but if the overall ratio is less than 91.3%, then the maxillary tooth material is excessive.

Anterior ratio: The sum of the mesiodistal diameter of the 6 mandibular anterior teeth should be 77.2% the mesiodistal widths of the 6 maxillary anterior teeth. If the anterior ratio is greater than 77.2%, then the mandibular anterior tooth material is excessive. This means that orthodontic treatment will end with Class II canine relationship because the mandibular canine is more distal. But if the anterior ratio is less than 77.2%, then the maxillary anterior tooth material is excessive. This means that orthodontic treatment will end with Class III canine relationship because the maxillary canine is more distal.

In the case of discrepancy, reduction of tooth material can be done on the arch with excess material or composite buildups on the arch with decreased tooth material. If the arch length discrepancy is:

- 0 to 2.5 mm - Proximal stripping can be carried out to reduce the minimal tooth material excess.
- 2.5 to 5 mm - Extraction of 2nd premolar is indicated
- Greater than 5 mm - Extraction of first premolar is usually required.

Drawbacks of Bolton Analysis:

1. This study was done on a specific population.
2. It doesn't take into account gender difference in the maxillary canine widths.

REFERENCES:

Graber LW, Vanarsdall Jr. RL, Vig KWL, Huang GJ. (2017): Orthodontics: current principles and techniques. 6th ed. Elsevier Health Science.

Littlewood SJ, Mitchell L. (2019): An introduction to orthodontics. 5th ed. Oxford University Press.

Phulari BS. (2011): Orthodontics: principles and practice: JP Medical Ltd.

Proffit WR, Fields HW, Larson BE, Sarver DM. (2019): Contemporary orthodontics 6th ed. Philadelphia: Mosby.

Singh G. (2015): Textbook of orthodontics. 3rd ed. JP Medical Ltd.

YouTube LINKS:

Channel: www.youtube.com/c/akramadp

Lecture: https://youtu.be/K4Ey1NjdgcM