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Correction of sagittal discrepanciesin orthodontics- a review

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ABSTRACT

Three planes of discrepancies are commonly described in orthodontics; namely sagittal, transverse and vertical. Of these, sagittal discrepancies are most commonly encountered in day-to-day practice. The sagittal discrepancies in orthodontics are mainly associated with the antero-posterior relationship of jaws, assessment of which is of great clinical importance in both the diagnosis and treatment planning. Proper examination, diagnosis and treatment planning is essential for both the orthopaedic and orthodontic management of various Class II and Class III clinical situations. This article emphasis on the systematic approach to the diagnosis and treatment planning of various sagittal discrepancies based on treatment goals, treatment options at various stages of development and their resolution with appropriate treatment mechanics along with long-term retention and stability.

Keywords: Sagittal discrepancies, diagnosis, treatment planning

I. INTRODUCTION

In orthodontic diagnosis and treatment planning, three planes of discrepancies are commonly described namely, transverse, sagittal and vertical. Sagittal discrepancies are usually assosciated with antero-posterior relationship of jaws.[1] Traditionally, orthodontic assessment and diagnosis is mainly based on Angle's sagittal classification of malocclusion. Since the dentofacial abnormalities exist in sagittal, transverse and vertical planes, contemporary orthodontic assessment and interpretation must include their understanding in all three dimensions.[1]

The sagittal discrepancies essentially include Class I, Class II and Class III malocclusions. Originally, these abnormalities represent the anteroposterior relationship between the maxillary and mandibular first permanent molars as described by Edward H. Angle.However, this approach does not recognize the dysplastic skeletal sagittal relationship of the maxilla and mandible to each other and to the cranial base.[2]

The following article emphasis on the systematic approach to the diagnosis and treatment planning of various sagittal discrepancies based on treatment goals, treatment options at various stages of development and their resolution with appropriate treatment mechanics along with long-term retention and stability.[3]

DEVELOPMENT OF SAGGITAL DISCREPANCIES

Various factors play an important role in the development of sagittal discrepancies. Growth disturbances, tooth size, crowding or spacing of teeth, height of palate and length and width of arch are all influenced by heredity. Apart from that, certain factors such as trauma during pregnancy or child birth, congenital defects, disturbances in eruption sequence, and local factors like anomalies in number of teeth, form, position and abnormal oral habits also significantly contribute to the

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development of Class II and Class III malocclusions.[3]

CLASSIFICATION OF VARIOUS TYPES OF SAGGITAL DISCREPANCIES OF JAWS

(1) Class II Malocclusion occurs when the distobuccal cusps of the upper first permanent molar occlude in the mesiobuccal groove of the lower first permanent molar.[4]

TYPES:

- Class II Div 1 Malocclusion is characterized by proclined upper incisors with a resultant increase in overjet.
- Class II Div 2 Malocclusion is characterized by Class II molar relationship with retroclined upper central incisors that are overlapped by the lateral incisors.[4]

CLASS II DIV 1	CLASS II DIV 2
Convex facial profile	Straight facial profile
Leptoproscopic facial form	Europroscopic facial form
Hypotonic short upper lip with lip trap	Normal and competent lips
Deep mentolabial sulcus	Normal mentolabial sulcus
Increased LAFH	Decreased/Normal LAFH
Deep palatal vault	Normal palatal vault
Constricted V-shaped arch form	Normal or square shaped arch
Increased overjet	Decreased overjet
Normal path of mandibular closure	Backward path of mandibular closure

(2) Class III Malocclusion occurs when the mesiobuccal cusp of upper first permanent molar occludes between mandibular first and second molar.[5]

TYPES:

- True Class III
- Pseudo Class III/ Habitual Class III/ Functional Class III.[5]

TRUE CLASS III	PSEUDO CLASS III
Concave facial profile	Straight/ Concave facial profile
Forward path of mandibular closure	Deviated path of closure
Retroclined/Normal lower incisors	Proclined lower incisors
Increased gonial angle	Normal gonial angle
Mandible cannot be further retruded beyond edge-to-edge position.	Mandible can be further retruded.

DIAGNOSIS

- Requires proper examination of the **Case history.**
- **Extra-oral and Intra-oral Examination**: It is done to assess the clinical features of the malocclusion present.
- **Study casts and models**: Used to assess Inter-arch and intra-arch relationship and occlusal relationship of molars and canines, to determine the amount of spacing/crowding, to evaluate the arch size-tooth material discrepancies within the jaw.
- **Photographic records**: To assess patient's soft tissue and hard tissue profile, facial form, symmetry and assessment of smile, to evaluate the progress of the treatment and to evaluate craniofacial relationships before and after the treatment.[4]
- **Radiographic records**: Includes OPG (for assessment of stages of tooth eruption, presence of any missing, supernumerary, impacted or ectopically present teeth and certain pathological conditions such as cyst or tumor.) and Lateral Cephalometric Radiograph (to evaluate the relationship of jaws and teeth, to determine the age by assessing the skeletal growth maturity indicator).[6]
- **Cephalometrics**: Used to assess the spatial relationship between cranium and jaws, within jaws themselves, between different points within the same jaw, relationship of incisors to the jaw bases and the plane of reference with regard to axes and position and relationship of facial thirds to each other. To determine the sagittal jaw base relationship, various

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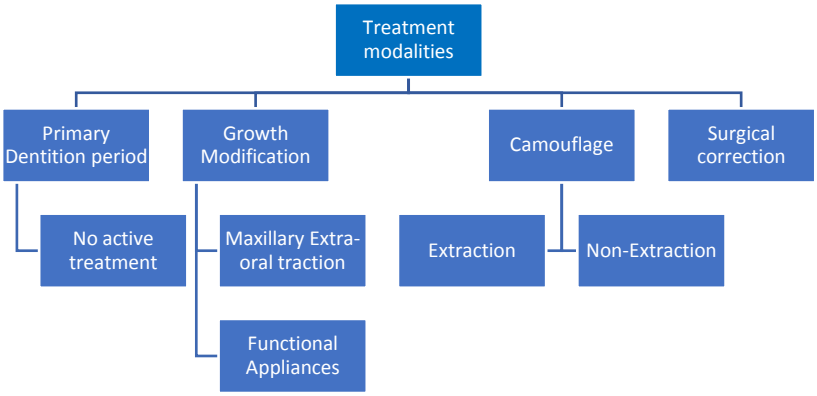
cephalometric analysis have been proposed such as SNA angle, SNB angle, ANB angle, Wits Appraisal, AF-BF, APDI, FABA, Beta angle, μ angle, YEN angle, W angle and Pi angle.[2]

MANAGEMENT

There are several treatment strategies available to manage different types of Class II/III situations. These cases require one or combination of various available treatment strategies. This include movement of teeth and alveolar processes, guidance of eruption and alveolar development, differential restraint and control of skeletal growth, differential promotion of skeletal growth, translation of parts during growth, training of muscles and surgical translation of parts.These malocclusions can be either dentoalveolar or skeletal.[6]



Treatment Modalities for correction of Skeletal Class II/III Malocclusions

Early Treatment: The sagittal dental discrepancies in the primary dentition, seen in children having sucking habits, are expressed in the form of anterior displacement of upper incisors and posterior displacement of lower incisors, loss of vertical contact with the mandibular incisors, narrowing of the maxillary arch and development of anterior open bite. During this phase, children should be carefully examined and assessed for existing and potential or developing discrepancies. The development of a space discrepancy when primary first or second molars are missing is best prevented by space maintenance protocol which is indicated when there is adequate space available, and the premolar eruption will take more than 6 months. One of the basic requirements of any mixed dentition treatment protocol is to monitor the transition from the mixed to the permanent dentition. This will help to resolve minor to moderate tooth-size and arch-size discrepancies along with the other methods of space gaining.[6]

Following are the treatment options for correction of class II/III malocclusion in growing patients:

1. Growth modification-

i) Extraoral appliances.

ii) Intraoral appliances- a. Removable functional appliances

b. Fixed functional appliances (rigid, flexible, hybrid)

2. Dental camouflage-

i) Non-Extraction (molar distalization)

ii) Extraction

3. Inter-arch traction (Elastics)

4. Combined Growth Modification

5. Surgical Correction

I. GROWTH MODIFICATION:

The goal of growth modification is to alter the unacceptable skeletal relationships by modifying the patient's remaining facial growth to favourably change the size or position of the jaws. Orthopaedic appliances are one of these appliances that are used to modify the growth of maxilla/ mandible.[7]

❖Basis for orthopaedic appliances:

Orthopaedic appliances use teeth as "handles" to transmit forces to the underlying skeletal structures. These appliances produce intermittent forces of very high magnitude which when directed to the basal bone via teeth tend to alter the magnitude & direction of the jaws by modifying the pattern of bone apposition at periosteal sutures and growth sites. Following are the basic principles of using orthopaedic appliances effectively:

a. **Amount of force**: The force magnitude should be high i.e., 400-600gm/side(headgear), 450gm/side(facemask)

b. **Duration of force**: Extraoral appliances should be worn for about 12-14 hours/day.

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c. **Direction of force**: Directed posteriorly and superiorly through the Centre of resistance of maxilla(headgear), 15-20 degrees downwards to occlusal plane(facemask)
d. **Age of the patient**: Orthopaedic appliances are most effective during the mixed dentition period.
e. **Timing of force application**: Since there is an increase in the release of growth hormones more during the evening and night so it is advisable for the child to wear the appliance in the evening and throughout the night.[7]

❖**EXTRA-ORAL APPLIANCES**:
The followings are the commonly used orthopaedic appliances:
a. Headgear
a. Facemask
b. Chin cup

HEADGEAR: Indicated in patients with excessive horizontal growth of the maxilla with/without vertical changes along with some protrusion of maxillary teeth, reasonably good mandibular dental and skeletal morphology. It is also used to distalize the maxillary dentitions along with the maxilla.[8]

➢**Components of headgear**:
1) **Force delivering unit**: Such as face bow and J hook
a. **FACE-BOW**: It is a metallic framework attached to teeth either via brackets (fixed orthodontic appliances) or removable appliances. This helps in delivering extraoral force to the posterior teeth. Parts of face bow includes Outer bow, Inner bow and Junction.
b. **J HOOK:** It consists of curved wires whose ends form hooks contoured to fit on the anterior segment of the maxillary arch wire. The site of attachment on the archwire is between the lateral incisors and the canine. Therefore, it is used along with maxillary fixed appliance having a continuous arch wire to retract maxillary anterior teeth.[8]
2) **Force generating unit:** Connects the face bow to the anchor unit and delivers forces to the teeth and underlying skeletal structures. This unit may comprise of either springs, elastics, or other stretchable materials.
3) **Anchor unit:** The headgear appliance derives anchorage from extra oral anchorage sites such as, rigid bones of skull (occipital), back of the neck(cervical) or a combination of them.

Various types of headgears used according to anchorage are Occipital pull headgear, Cervical pull headgear, Combination headgear, Vertical pull headgear, Asymmetric headgear.[8]

FACEMASK: Also called "protraction headgear" or "reverse pull head gear" or Delaire facemask. It is used to treat class III malocclusions due to the combination of maxillary deficiency and mandibular excess in growing patients. It aids in pulling the maxillary structures forward and pushing the mandibular structures backward.[9]

➢**Components of facemask**:
1. **A rigid metal extraoral framework**: Connects the various components such as the chin cup and the forehead cap.
2. **Chin cup or pad**: It takes anchorage from the chin area and usually connected to the rest of the facemask assembly by means of metal rods.
3. **Forehead support or cap or strap**: Used to derive anchorage from the forehead area.
4. **Heavy elastics**: Used to apply a forward traction on the upper arch. The vertical posts of chin cup are used to attach the elastics onto the upper molars or hooks soldered on the upper arch wire.
5. **Intraoral appliance**: It is the most common type of protraction device is a multibanded appliance with a ridge wire. Traction hooks are placed either in the molar or premolar region.[9]

\
CHIN CUP: Extraoral orthopaedic device that covers the chin and is connected to a headgear. Used to restrict or redirect the growth of mandible. Therefore, it is indicated to treat class III malocclusion due to a protrusive mandible but a relatively normal maxilla.[10]

➢ **Components of chin cup:**
1. **Force module**: ex. Elastics/metal springs that provide the desired tension levels on the chin cup.
2. **Chin cup**
3**. Head cup**
Generally, chin cups are of two types- Occipital pull and Vertical pull chin cups.[10]

❖ **INTRA-ORAL APPLIANCES:**
FUNCTIONAL APPLIANCES: The term "functional appliance" refers to a variety of removable appliances designed to alter the arrangement of various muscle groups that influence the function and position of the mandible in order to transmit forces to the dentition and the basal bones.[11]
Indications:
✓ Mandibular deficiency with a normal maxillary development

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✓ Normal or slightly decreased facial height
✓ Slightly protrusive maxillary incisors and slightly retrusive mandibular incisors with active mandibular growth primarily in the forward direction.[11]

Skeletal effects of functionalappliance: Causes downward and forward remodeling of the glenoid fossa that leads to the skeletal Class II correction. Since the appliance contacts the maxilla and the maxillary teeth, it also leads to restriction of the maxillary growth.[11]

Dental effects of functional appliances: Causes lingual tipping of the maxillary anteriors by the labial bow or the torquing springs, affects the mandibular posteriors by encouraging their mesial and occlusal eruption while inhibiting the eruption of maxillary posterior teeth.[11]

Limitations of functional appliances:

- Cause extrusion of maxillary and mandibular molars.
- Individual tooth movements are difficult.
- Treatment results are totally dependent on patient cooperation.
- Ineffective in non-growing patients.[11]

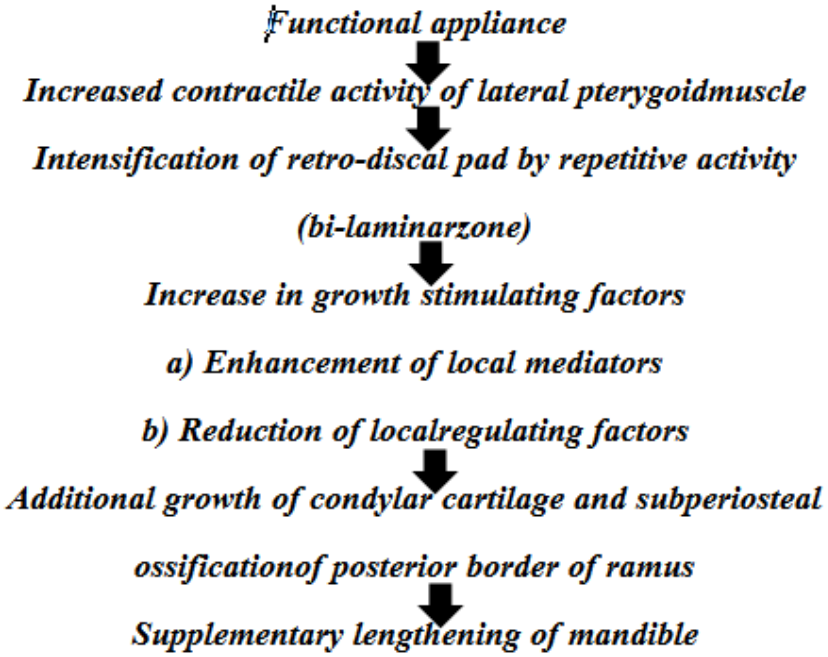
Some of the commonly used Removable functional appliances are- Activator, Bionator, Frankel functional regulator, Twin block, Bioblock, Reverse Twin block etc.[11]

FIXED FUNCTIONAL APPLIANCES: Also known as Non-Compliance class II correctors and they have some advantages over removable systems:

- Designed to be worn 24 hour a day.
- Smaller in size permitting better adaptation to function
- Reduce the need for patient compliance.
- As they are fixed on the upper and lower arches, they transmit forces directly to the teeth.[12]

Indications:

✓ In young growing individual- In skeletal class II patients with retrognathic mandible and in skeletal class III patients with retrusive maxilla.
✓ Making use of the residual growth left in neglected post adolescent patients who have passed the maximal pubertal growth and are too old for removable functional appliances.
✓ In adult patients to distalize the maxillary molars in correction of dental class II molar relationship and to enhance anchorage.
✓ Can be used as a mandibular anterior repositioning splint in patients having temporomandibular joint disorders.
✓ Correction of functional midline shifts by using the appliance unilaterally.[12]



Flowchart showing mechanism of action of fixed functional appliances

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Complications:

- Breakage of bands or splints.
- Breakage of telescoping mechanisms.
- Loosening of bands or splints.
- Trauma to buccal mucosa[12]

Some commonly used Fixed functional appliances are Herbst appliance, MARS appliance, Jasper Jumper, MARA, Forsus Fatigue Resistant Device, PowerScope, Advansync etc.

INTER-ARCH ELASTIC TRACTION

Intermaxillary elastics are commonly used in orthodontic treatment for correction of Class II and Class III relation. It is of two types:

- **Class II Elastics**: Interarch traction from the anterior part of the maxillary arch to the posterior part of the mandibular arch. This results in protraction of the mandibular posteriors and retraction of the maxillary anteriorsto bring about a Class I molar relation.[13]
- **Class III Elastics**: Interarch traction from posterior part of maxillary arch to the anterior part of mandibular arch. This results in retraction of mandibular posteriors and protraction of mandibular anteriorsto bring about a Class I molar relation.[13]

Complication: Since Class II and Class III intermaxillary elastics both exerts a vertical and a horizontal component of force.Therefore, the vertical vector in both types of malocclusions extrudes the teeth, tips the occlusal plane, and thereby causes a rotational opening of the mandible.[13]

COMBINED GROWTH MODIFICATION

It combines both the orthodontic and the orthopaedic phases into a cohesive fixed orthodontic therapy.While headgears correct Class II skeletal patterns by maxillary restriction and functional appliances by promoting mandibular growth, the skeletal effects of the two are similar and hence both began to be used in combination. This is usually used in cases of more severe skeletal Class II problems with a vertical maxillary excess being a prominent feature.

DENTAL CAMOUFLAGE

The goal is to disguise the unacceptable skeletal relationship by orthodontically moving the teeth to get proper buccal occlusion and ideal overjet and overbite.

A. Dental camouflage without extractions:When sufficient space is not available in the arch, maxillary molar can be distalized by a continuous headgear wear, only if second molars have not been erupted. If the patient's compliance is questionable, an intraoral molar distalizer is used. [14]

- **MOLAR DISTALLIZATION:**

Indications:

- ✓ To mesially position the maxillary first molar
- ✓ Patients with low mandibular plane angle (brachycephalic type) or normal (mesocephalic type)
- ✓ Mild to moderate class II molar relationship, which are not indicated for extraction
- ✓ To correct the second molar position
- ✓ To achieve ideal overbite and overjet
- ✓ To regain the lost space (space regainer)[14]

Contraindications:

- ✓ Patients with high mandibular plane angle and excessive lower anterior facial height
- ✓ Patients with skeletal or dental open bite
- ✓ Severe class II skeletal pattern with an orthognathic maxilla and retrognathic mandible
- ✓ Excessive overjet and proclination of anterior teeth
- ✓ Crowding in the posterior segment
- ✓ Patients with temporomandibular joint problems.[14]

Various appliances used for molar distalization includes Headgear, Pendulum appliance, Pend-X appliance, Lip Bumper, Forsus appliance, Herbst Appliance, Japanese NiTi coils, Distal Jet, Ghoshgarian TPA, Carriere appliance with class II elastics, Sliding Jig, miniscrews etc.[14]

B. Dental camouflage with extractions: Factors that enforce extraction of teeth for orthodontic treatment includes increased tooth size in relation to the arch size (crowding), supernumeraries, hypodontia (if decided to close the space, may need extraction), carious teeth, increased overjet, open bite, impacted teeth, camouflage orthodontic treatment, correction of the buccal segment, malformed teeth, periodontally involved teeth, orthognathic surgery, cleft lip, and palate.[15]

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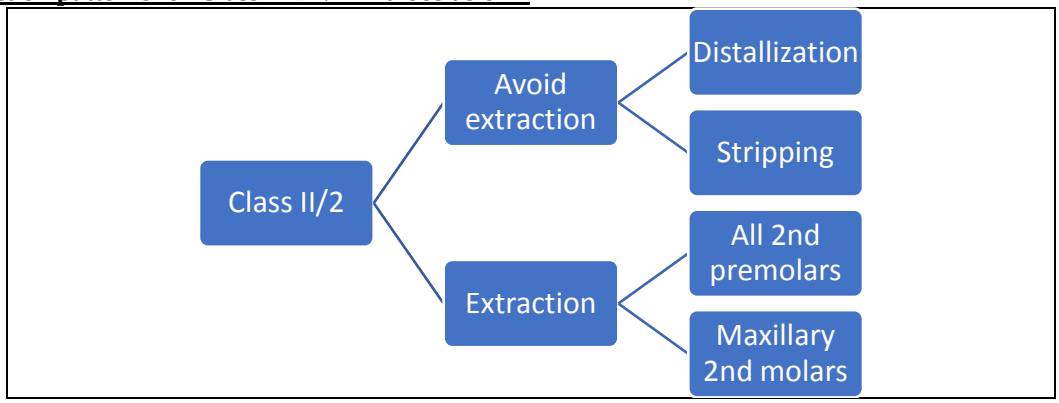
Extraction pattern for various malocclusions are as follows:

CLASS I	**Patterns**																			
	1		**2**		**3**		**4**		**5**						**6**		**7**			
	4	**4**	**5**	**5**	**6**	**6**	**7**	**7**	**4**	**5**	**4**	**6**	**5**	**6**	**2**	**2**				
	4	**4**	**5**	**5**	**6**	**6**	**7**	**7**	**4**	**5**	**4**	**6**	**5**	**6**	**5**	**5**	**1**			**1**

CLASS II/ DIV 1	**Patterns**													
	1		**2**		**3**								**4**	
	4	**4**	**4**	**4**	**4**	**4**	**6**	**6**	**7**	**7**	**2**	**2**	**2**	**2**
	4	**4**	**5**	**5**									**5**	**5**

Extraction patterns for Class I Malocclusion[15]

Extraction patterns for Class II Div 1 Malocclusion[15]



Extraction patterns for Class II Div 2 Malocclusion[15]

CLASS III	**Patterns**													
	1		**2**		**3**		**4**		**5**				**6**	
	5	**5**			**4**	**4**	**6**	**6**	**5**	**4**	**5**	**6**	**4**	**4**
	4	**4**		**1**	**4**	**4**	**6**	**6**	**4**	**4**	**4**	**6**	**5**	**5**

Extraction patterns for Class III Malocclusion[15]

SURGICAL CORRECTION

Orthognathic surgery may be planned in patients with severe skeletal discrepancy or extremely severe dentoalveolar problem and adult patient, or younger patient with severe skeletal deformity.[16]

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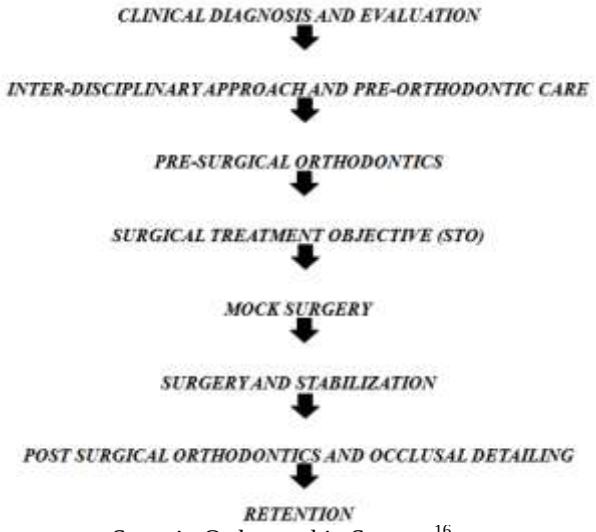

Steps in Orthognathic Surgery[16]

SURGICAL METHODS FOR CORRECTION OF ANTERO-POSTERIOR DISCREPANCIES:

1. **MAXILLARY SURGERIES**: The maxilla can be virtually moved in all the three planes by Le Fort I surgery.
   - Can be advanced by Le Fort I down-fracture and interposing grafts in retromolar area.
   - Can be retracted by anterior segmental osteotomies and retraction of anterior segment into first premolar extraction space.[17]

2. **MANDIBULAR SURGERIES**:

BSSO is used for both the advancement and retraction of the mandibular ramus but it is commonlyused for mandibular setbacks as condylar segments are easily controlled.[18]

II. CONCLUSION

The sagittal discrepancies in orthodontics mainly include the deformities of jaws that are present in antero-posterior plane. A large portion of sagittal discrepancies are often associated with a variety of combinations of significant skeletal, dental and functional imbalances not just in anteroposterior plane but in vertical as well as transverse plane. In dealing with these malocclusions, contemporary orthodontic assessment and interpretation must include their proper understanding with respect to the recognition of various components involved and their interaction with the sagittal dimension. However, it should be recognized that the reliable identification of such cases requires the development of extensive diagnostic skills.This literature has provided the systematic approach to the diagnosis and treatment planning of various sagittal discrepancies based on refined treatment goals, treatment options for various stages of development and their resolution with appropriate treatment mechanics and long-term retention and stability.

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