Journal Homepage: -www.journalijar.com

INTERNATIONAL JOURNAL OF ADVANCED RESEARCH (IJAR)

Article DOI:10.21474/IJAR01/11205
DOI URL: http://dx.doi.org/10.21474/IJAR01/11205

*RESEARCH ARTICLE*

# CLASS III MALOCCLUSION - SYSTEMATIC REVIEW OF CURRENT TRENDS, PRACTICES AND CHALLENGES

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## *Manuscript Info*

***Manuscript History***
Received: 15 April 2020
Final Accepted: 18 May 2020
Published: June 2020

***Key words:-***
Class III Malocclusion, Prevalence, Treatment Options, Review, Treatment

## *Abstract*

Class III malocclusion are easy to diagnose but often difficult to treat. The presentation of Class III condition is vivid in nature and require in-depth analysis of clinical features, cephalometric evaluation, differential diagnosis, treatment options, controversies regarding treating modalities, prognosis, relapse and stability. Class III condition presents with an array of clinical problem with each feature indicating a peculiar fault in the stomatognathic system. There are various cephalometric analysis to assist in reaching a definite diagnosis and most viable treatment option for a particular case. Similarly, there are many treatment options according to the age, growth status, severity of the problem and socio-psychological status of the patients. Even after treatment, Class III is prone for relapse and requires long-term stability. This review article discusses in detail about the current trends and challenges in most aspects pertaining to the diagnosis and treatment planning of Class III malocclusion. The advances in surgery-first approach, 3-dimensional imaging and surgical movements are also discussed in this review article.



## Introduction:-

The human face is the world's most recognisable container of information. Due to the amalgamation of population, races, religion and genetic variation, the concept of facial beauty has become zestful. Class III malocclusion has always been a topic of interest and controversies throughout, for all researchers across the globe. Angle for the first time in 1899 described Class III malocclusion as the anterior placement of mandibular first molar in relation to the maxillary first molar (Angle, 1899). Though associated with many flaws, this Angle's classification of Class III malocclusion was simple and easy to use. Perceptibly, with time Angle's classification was improved to include skeletal jaw relationship and growth patterns. Now, a Class III condition suggested that the mandible is positioned mesial to the maxilla and/or cranial bases irrespective of the molar relationship. Tweed in 1966 classified class III malocclusion as pseudo-Class III (Category A) and skeletal Class III (Category B) (Tweed, 1966). Pseudo-Class III malocclusion represents a normal/conventional mandible and an underdeveloped maxilla. Skeletal Class III malocclusion represents a prognathic mandible and/or underdeveloped maxilla. Park and Baik in 2001 classified Class III malocclusions into three types. Type A/true mandibular prognathism – normal maxilla and prognathic mandible,Type B – overgrown maxilla and mandible with anterior crossbite and Type C – maxillary hypoplasia with anterior crossbite, obtuse nasolabial angle and concave profile (Park and Baik, 2001). Class III malocclusion can also be classified as congenital and developmental. A congenital class III malocclusion results from congenital anomalies of the maxilla and mandible or prepubertal trauma of the face and manifests clinically as anterior

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crossbite of the deciduous dentition. Developmental class III malocclusion manifests after pubertal growth with anterior crossbite and mandibular prognathism occurring concomitantly. A hybrid malocclusion is a more severe form representing the features of both congenital and developmental malocclusion. Class III conditions are easy to diagnose but difficult to plan, treat and retain. The aim of this article is to present a detail analysis of prevalence, aetiology, diagnosis, treatment modalities and management of Class III malocclusion, considering the present trend and evidence available in the orthodontic literature.

**Prevalence:**

A class III condition can be both socially and functionally handicapping. Due to the dynamic nature of the Class III problem, this malocclusion varies considerably between populations, races, ethnic groups and geographic regions. A systematic review and meta-analysis reported a global prevalence of Class III malocclusion in the wide range of 0% to 26.7% (Hardy et al., 2012). This wide range can be attributed to the variation amongst samples, growth period of examination and sample analysis. Highest prevalence of Class III malocclusion was found in the Chinese and Malaysian population, and the lowest in the Indian population when compared to other racial groups. In the Omani adolescent population, the prevalence of Class III malocclusion was found to be 4.2% (Jadidi et al., 2018). A prevalence of 9.48% was found in Kuwati population (Behbehani et al., 2005). There is a large variation among and within the population regarding the prevalence of Class III malocclusion. Hence it is recommended to have a standard protocol to study the method of prevalence of Class III malocclusion.

**Etiology:**

The aetiology of Class III malocclusion is complex, multifactorial and wide-ranging. It can be attributed to genetic/familial causes or environmental factors or a combination of both. Class III malocclusions have been known to have a strong familial nature as first reported by Strohmayer in 1937 as noted by Wolff et al. in their analysis of European Hapsburg family (Wolff et al., 1993). Litton et al. in his study has shown the familial genetic inheritance of mandibular prognathism in off springs and siblings (Litton et al., 1970). Environmental factors like deleterious oral habits, wrong posture, enlarged tonsils, adenoids and chronic mouth breathing can lead to the downward and backward growth of the mandible. Also, premature loss of primary teeth, cleft lip and palate, enlarged tongue, atypical swallowing, nasal blockage, hormonal disturbances like gigantism and pituitary adenoma can lead to the development of Class III problem (El-Gheriani et al., 2003). Understanding the cause of the resultant problem is important to successfully treat it.

**Elements of class iii malocclusion:**

The variation seen in a class III malocclusion is due to the imbalance in the shape, size and position of the cranial base, maxilla and mandible in respect to each other along with the involvement of dentoalveolus and soft tissue. It is associated with a maxillary retrognathism, mandibular prognathism or combination of both. On a lateral cephalogram the length of the anterior cranial base (N-S) and posterior cranial base (S-Ar/Ba) is reduced implying a short or hypoplastic mandible (Ngan et al., 1997). The saddle angle (N-S-Ar) is reduced and the gonial angle (Ar-Go-Gn) is increased signifying a more forward positioning of the glenoid fossa resulting in Class III malocclusion (Baccetti et al., 1997). ANB, Wits, maxillomandibular differential, Nasion perpendicular to Point A and condylion to gnathion are some other cephalometric measurements. According to Ellis and McNamara, combination of maxillary retrusion and mandibular protusion is the most common skeletal relationship seen in Class III patients (Ellis and McNamara, 1984). Chen et al. has found that the maxillary skeletal base width and maxillary intermolar widths are significantly smaller in Class III than in the Class I group (Chen et al., 2008). According to Staudt and Kiliaridis, Class III patients tend to have a more hyperdivergent facial dimension with increased lower anterior facial height (Staudt and Kiliaridis, 2009). Dentally, pateints have proclined upper incisors and retroclined lower incisors with an edge-to-edge bite or anterior crossbite to compensate for the anteroposterior sagittal skeletal discrepancy along with a class III molar and canine relationship. These components of class III malocclusion show wide variation and mar vary between different racial and ethnic groups.

**Diagnosis of class iii malocclusion:**

Class III malocclusions are easy to identify because of their ‘witch-look’ appearances. The facial profile is concave with a prominent chin or a small midface. This problem can be both socially and functionally handicapping. Firstly, a family history of a similar condition would always be handy. Clinically, any anterior crossbite or mandibular prognathism should be observed. The profile of the patient should be evaluated in natural head position (NHP). A concave profile usually indicates a skeletal Class III jaw relationship. A lateral cephalometric assessment of earlier mentioned parameters should be done to identify the fault in the anterior cranial base, maxilla or mandible. It is also

important to differentiate a true skeletal Class III malocclusion with a pseudo Class III malocclusion. An abnormal tooth contact/interference in centric relation (CR) can lead to the anterior positioning of the mandible in centric occlusion (CO) (Hidaka et al., 2002). Such cases have class I dental and skeletal pattern, straight profile in CR but a class III dental and skeletal pattern in CO. Moreover, the lower incisors are lingually inclined to compensate for the negative overjet thereby achieving a positive overjet or an edge-to-edge incisor relation. In such cases of Pseudo Class III malocclusion, elimination of the interferences/CO-CR discrepancy leads to a normal class I molar relationship. If the class III molar relationship persists then it should be considered a case of compensated class III malocclusion where the mandible has permanently repositioned anteriorly due to the continuous presence of a functional shift (Rabie, 2000).

The wide range of variation in the magnitude and expression of Class III malocclusion can lead to a difficulty in diagnosis. Figure 1 represents an outline of the assessment and diagnosis of Class III problem.

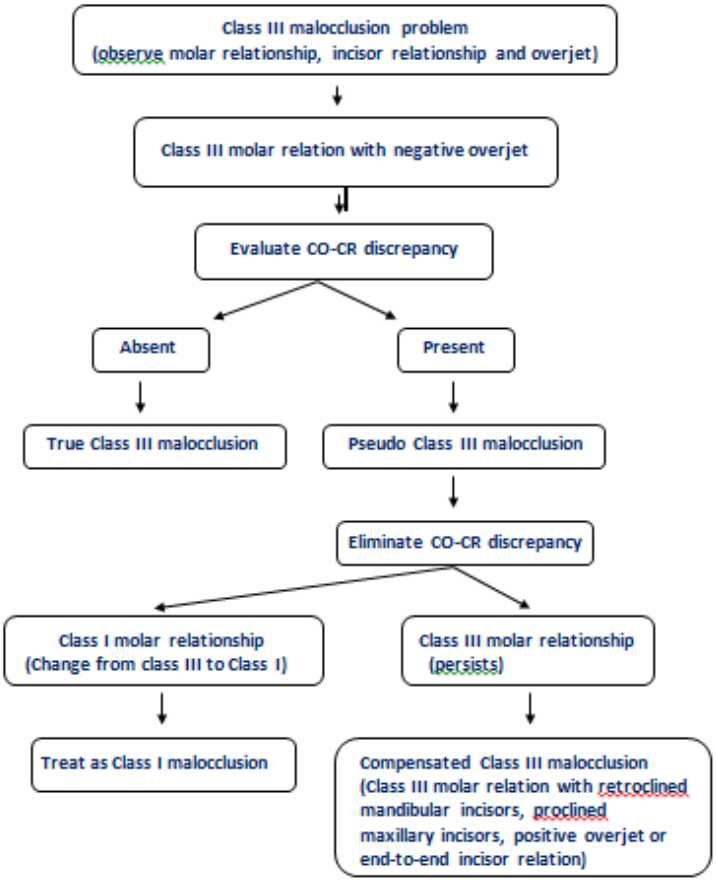


**Figure 1:-** Flowchart summarizing the outline of assessment and diagnosis of class III malocclusion.

**Strategies in the treatment of class iii malocclusion:**

Assessment of growth is the most important factor to be considered when evaluating a case of Class III malocclusion. According to Mitani, the basic pattern of mandibular prognathism is established before puberty and doesn't change fundamentally (Mitani, 2002). Selecting the appropriate appliance for the particular age group affects the prognosis and long-term stability of treatment outcomes. The prognosis of the treatment is always guarded until the growth is completed. On the basis of growth, Class III malocclusions can be divided into developing and non-developing malocclusions (Ngan, 2006). Figure 2 represents an outline of the treatment strategies involved in treating a case of Class III malocclusion.

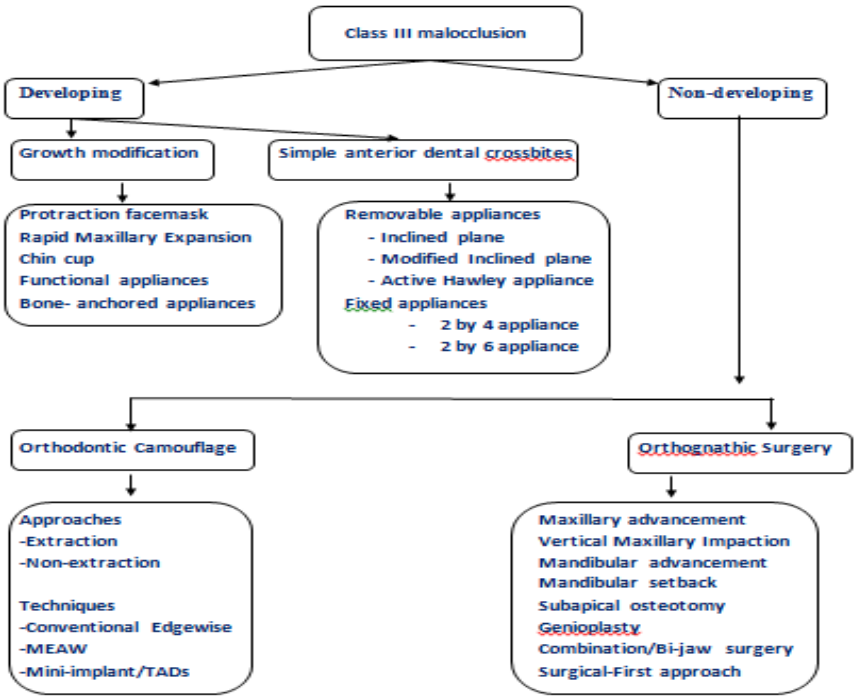


**Figure 2:-** Outline of the treatment strategies involved in treatment of Class III malocclusion.

**Treatment of developing class iii malocclusions:**

Cases in which the growth potential is remaining can be treated by growth modification of the maxilla or the mandible. The objective of early treatment in such cases is to promote the favourable and normal growth of the oro-facial skeletal, dental and soft-tissue complex (Campbell, 1983). For enhanced orthopaedic effect, the treatment in such cases should be done in patients with less than 10 years of age (Baccetti, 1998; Kim et al., 1999; Battagel, 1995). Some studies however suggest that the age of the patient has little influence on the treatment response and outcome (Kapust et al., 1998; Atalay, 2010). Growth modification approaches involves the use of protraction facemask, rapid maxillary expander, chin cup, functional appliances and bone-anchored appliances. Simple anterior crossbite in mixed dentition can be treated with removable appliances like inclined plane, modified inclined plane, active Hawley appliance and fixed appliances like the 2 by 4 or 2 by 6 appliances.

**Protraction facemask:**

**History:**

The evolution of orthopaedic treatment in orthodontics started when Fauchard in 1728, first described the bandeau, a horse-shoe shaped expansion arch. Angell proposed a split plate to open the median palatal suture of the maxilla (Asbell, 1990). Haas with his own appliance expanded the maxilla to advance it anteriorly (Hass, 1970). Until 1970s, Class III malocclusion was synonymic with mandibular prognathism. Landmark studies by Masaki (Masaki, 1980) and Guyer (Guyer et al., 1986) reported that majority of Class III malocclusion is associated with a deficient/short maxilla, reduced anterior cranial base and obtuse gonial angle.

**Indication:**

Protraction facemask is indicated to intercept developing Class III malocclusion with hypoplastic or short maxilla. The optimum timing of intervention is in the pubertal growth phase with a chronological age up to 8 years in girls and 9 years in boys (Westwood, 2003). Maximum skeletal response is obtained in the cervical vertebral maturation stages 1 and 2 (CS1-CS2) and hand wrist maturation (SMI1-SMI2) (Baccetti et al., 2001). Studies have found out that protraction facemask is less effective in patients older than 10 years of age (Battagel, 1995).

**Types:**

Protraction facemask alone (banded or bonded)
Protraction facemask with Rapid Maxillary Expansion (RME)

Facemask with Bone-anchored Maxillary Protraction (BAMP)
Corticotomy-assisted maxillary protraction

**Protraction facemask alone:**
They can be banded or bonded on the maxillary dentition as an anchorage for the maxillary protraction. A bonded appliance is indicated in patients with an increased lower facial height as it provides a temporary biteplane effect. Also it is indicated in cases of deepbite or overclosure of the mandible as it facilitates the jumping of the anterior crossbite (Watkinson et al., 2013).

**Protraction facemask with RME:**
McNamara followed by Turley, corrected and presented cases of Class III malocclusion with maxillary deficiency using an expansion appliance on the maxillary arch (McNamara, 1987; Turley,1988). Maxillary expansion disarticulates the maxilla and loosens the circumaxillary sutures to allow a more favourable anterior movement of the maxilla (Nanda, 1984). Most patients with skeletal class III problems concomitantly have a constricted maxilla in the transverse and sagittal dimension clinically featuring as crossbites. In such cases it is suggested to use an RME appliance to mechanically stretch the sutures and protract the maxilla with a facemask to induce new bone formation (Zhang et al., 2015). The expansion appliance is activated two times a day (0.25 mm per turn) for 7-10 days. In severe maxillary constriction, appliance activation can be done for a period of more than two weeks. Liou suggested a protocol of repetitive weekly alternate expansion and constriction of the maxilla for 7-9 weeks to disarticulate it without overexpanding (Liou, 2005). Studies have shown that this expansion-constriction protocol resulted in forward movement of the maxilla and significant increase in the upper airway volume (Yilmaz, 2014). Treatment timing is clinically important when using RME as midpalatal and circumaxillary sutures are broad and smooth before 8 years of age and become heavily interdigitated around puberty (Melsen, 1982). Hence greater degree of anterior maxillary displacement can be expected when treatment is initiated in primary or early mixed dentition phases. A large raging controversy is the clinical effectiveness of using facemask with or without RME. A recently concluded randomized control trail (RCT) and meta-analysis have found that facemask with or without RME is equally effective in early treatment of Class III malocclusions (Liu et al., 2015). But in cases of transverse maxillary constriction, facemask with RME yields better and stable results (Wilmes et al., 2014). Correction of overjet, backward movement of mandible, labial movement of maxillary incisors, lingual movement of mandibular incisors, forward movement of Point A and increase in ANB angle have been observed clinically and radiographically. An overcorrection of the molar relationship and overjet is highly recommended to overcome the unfavourable mandibular growth in the future. Shortcomings of using facemask and RME lies in the fact that these appliances lead to buccal tilting and extrusion of the maxillary molars, increase in vertical facial height, mesial movement of maxillary molars due to loss of anchorage, decreased arch length, proclination and crowding of anterior teeth (Cevidanes et al., 2010).

**Facemask with Bone-anchored Maxillary Protraction (BAMP):**
The afore said mentioned side-effects of tooth borne RME lead to the development of bone-anchored maxillary protraction (BAMP) appliances for treatment of class III malocclusions. Cevidanes et al. for the first time introduced BAMP appliance which involved the use of mini-plates anchored in infrazygomatic crest of the maxilla to the mini-plates anchored in mandibular symphysis region to protract the maxilla with Class III elastics (Cevidanes et al., 2010). This technique offers greater skeletal changes and maxillary advancement compared to conventional RME appliance, less unwanted displacement of dentition, vertical changes are better controlled no clockwise rotation of mandible and retroclination of mandibular incisors occurs (De Clerck et al., 2010). It is an effective alternate treatment appliance for class III malocclusion with hyperdivergent growth pattern (Ngan et al., 2015). Limitations of this technique lie in fact that it is a surgically invasive procedure and success relies on the placement technique, thickness and quality of maxillary bone. The maxillary bone quality is not optimum for placing mini-plates until 11 years of age hence BAMP is indicated in slightly older patients compared to conventional tooth-borne appliances (De Clerck et al., 2010).

**Corticotomy-assisted maxillary protraction:**
This technique involves performing LeFort I osteotomy followed by application of facemask on 7$^{th}$ day after surgery. A 4 mm advancement of maxilla has been observed using this modality of treatment (Rachmiel et al., 1999). It has been found to be more effective and efficient than facemask with RME for the correction of class III malocclusion (Nevzatoglu, 2014). But it should be borne in mind that it is an intense surgical procedure with its own

set of drawbacks and complications. More research is required to reach out at any conclusion regarding this approach.

**Chin cup appliance:**
Earlier it was believed that the chin cup therapy alter the mandibular form and condylar growth. Studies by Suguwara and Mitani, suggest that the mandibular position can be improved during the initial 2-3 years of chin cup therapy but such changes are often not maintained during the growth of the individual (Suguwara, 1990; Mitani, 2002). The skeletal profiles have a tendency to return to their original shapes and sizes which are pre-determined morphogenetically. Recovery growth can lead to recurrence of a prognathic and class III mandible. The use of chin cup is limited to correct anterior crossbite in first phase of still growing patients and in cases of mild-to-moderate skeletal class III malocclusion which can be later camouflaged by dentoalveolar compensation. A chin cup is recommended to be worn until completion of facial growth to retain the treatment effects of the appliance. It is contraindicated in patients with true mandibular excess and hyperdivergent facial growth as it leads to downward and backward rotation of mandible and increases the lower facial height. Such cases are best treated by orthognathic surgical procedures once their growth is completed (Tsolakis et al., 2016).

**Functional appliances:**
**Functional Regulator III (FR III):**
This appliance is indicated in early mixed dentition when maxillary incisors are erupting. The vestibular shield stretches the maxillary periosteum and promotes the anterior development of maxilla. It also restricts and repositions the mandible posteriorly. FR III can also be used as a retention appliance after facemask therapy. But this appliance is too bulky and difficult to wear in mouth, is prone to breakage, requires a long treatment time, excellent patient cooperation and principally produces only dentoalveolar effects (Ulgen, 1994).

**Reverse Twin-Block:**
In this appliance the blocks are positioned in such a way that there are anterior forces on the maxilla and posterior forces on the mandible. It can also be used as a retention appliance after orthodontic or orthognathic surgical treatment of class III malocclusion (Kinder et al., 2003).

**Removable appliances:**
Inclined planes can be used to correct simple anterior crossbites involving retroclined maxillary anterior teeth with or without functional shift, well aligned mandibular anterior teeth, normal to deep overbite and average to horizontal growth pattern. An active Hawley appliance with palatal Z spring can be used to correct anterior crossbite. Expansion Jack screws can be used to procline maxillary anterior teeth. These appliances are indicated if the problem is simple and only tipping movement of upper anterior teeth are required (Chang, 2009).

**Fixed appliances:**
They are know as ‘2 by 4’ or ‘2 by 6’ appliance. They are bonded posteriorly on the two maxillary first molars and anteriorly on the four incisors or six anterior teeth. These appliances are mostly indicated in late mixed dentition or early permanent dentition. The results with these appliances are quicker since the patient compliance is more and the speech is unaffected as compared to a removable appliance (Wiedel, 2015).

**Treatment of non-developing class iii malocclusions:**
After the diminution of growth at around 14 years for girls and 17 years for boys, non-developing malocclusion can be treated either by orthodontic camouflage or surgical approach. Since it is difficult to predict the pattern of late mandibular growth, it is judicious to wait until cessation of complete growth.

**Orthodontic camouflage or Orthognathic surgery? The decision making:**
Another arena of controversy in the treatment of class III malocclusion is the choice between orthodontic camouflage and orthognathic surgery. Many studies have been done over the years but this still remains a challenge to the speciality of orthodontics. Table 1 represents the favourable factors to be noticed in a case of class III malocclusion before treating by a particular modality (Ngan, 2015; Kerr et al., 1992).

**Orthodontic camouflage:**
There are different strategies, appliances and treatment goals when treating a patient with camouflage approach. The use of class III elastics is the mainstay of this treatment. Class III elastics alleviate the anteroposterior discrepancy

and relieve deepbite in low mandibular plane angle cases. For high angle cases it is recommended to use micro-implant to avoid undue increase in lower facial height. The upper anteriors are already compensated (tipped forward) hence they should not be further tipped forward during the orthodontic treatment. Hence, labial root torque should be applied when moving the upper incisors. Similarly, the lower incisors are already tipped lingually and hence the width of the labial bone plate should be evaluated before tipping the lower anteriors more lingually (Park et al., 2017). In cases of moderate class III problems, extraction can be performed depending upon the severity of malocclusion, crowding in the arches, Bolton's discrepancy and amount of negative overjet (Faerovig, 1999). Table 2 represents the extraction pattern to be followed based on the characteristics of the case.

Conventional edgewise appliances, Multiloop Edgewise Archwire (MEAW) technique and micro-implant can be used for orthodontic treatment. The MEAW technique proposed by Kim in 1967 is used to correct mild skeletal class III malocclusion with mesially inclined lower posterior teeth together with an open bite. This technique has been found to be useful in correcting cases from Korea, Japan and other East-Asian countries. Multiple L-shaped horizontal and vertical loops are fabricated in MEAW which requires complex wire bending. This technique requires 24 hours class III elastic wear else the open bite can become worse (Kim, 1987). Recently, use of temporary anchorage devices (TADs) like micro-implant has widened the scope of treatment options for class III patients (Hagg et al., 2003). TADs offer absolute anchorage, no patient cooperation is required, easy to place, reduce the amount of wire bending and provide effective and efficient movement of the teeth and dentition (Kuroda, 2012). Table 3 represents the use of microimplants in the treatment of class III malocclusion (Park, 2009).

Orthodontic camouflage is a viable treatment option in mild to moderate cases of class III malocclusion. The type of intervention, choice of appliance and the approach to treatment depends upon the indications of the case and the experience and expertise of the orthodontist.

**Orthognathic surgery:**

This treatment option is reserved for non-growing patients with severe skeletal class III malocclusion. Often surgery is the last option when the growth potential of the patient is ceased. Table 1 shows certain favourable factors for treating class III malocclusion by orthognathic surgery. According to Stellzig-Eisenhauer et al. Wits appraisal is the most decisive factor in differentiating between a surgical and non-surgical class III group (Stellzig-Eisenhauer et al., 2002). A Wits appraisal value of more than -5 mm is considered to be treated surgically. Most of the orthognathic surgical procedures are performed after the age of 18 years so that no interference of growth occurs in the treated cases (Ngan, 2006).

Hullihen in 1846 for the first time performed the osteotomy of the mandibular body in a prognathic mandible (Hullihen, 2004). With this began the history of orthognathic surgery in mandible. Trauner and Obwegeser described the sagittal split ramus ostetomy which marked the beginning of modern era in orthognathic surgery and today is known as bilateral sagittal split osteotomy (BSSO) (Trauner and Obwegeser, 1957). Next several decades saw improvement in the techniques and modification that allowed repositioning of the either jaw in all the three planes of space as desired by the surgeon and orthodontist (Ngan, 2015). Conventional surgical treatment of skeletal class III malocclusion includes maxillary advancement, mandibular setback or combination of both.

The mandible can be moved anteriorly or posteriorly, moved down or rotated, narrowed anteriorly but widened only with distraction osteogenesis (Bailey et al., 1995). Mandibular setback by BSSO is a common orthognathic surgical procedure. Greater amount of mandibular setback can lead to compromised airway and breathing problems while sleeping (Kitagawara et al., 2008). Subapical segmental osteotomy is an alternate for these patients. Lefort osteotomy with maxillary advancement is done in cases of class III maxillary horizontal deficiency to bring the maxilla forward. It is considered a highly stable procedure as compared to mandibular setback which is prone to relapse. Presently, bi-jaw surgical approach has gained more acceptance than single-jaw surgery. In isolated mandibular setback, condyles used to sag posteriorly in their sacs since patient is in supine position during the surgery. After the surgery, when the intermaxillary fixation is removed, the mandible moves anteriorly, mimicking a post-surgical relapse. Also in isolated advancement and downward movement of the maxilla, downward and backward movement of the mandible occurred leading to increased lower facial height. Hence, to avoid these surgical effects and to increase the stability of the procedure, nowadays most class III patients have a maxillary advancement combined with a mandibular setback known as bi-jaw surgical intervention (Proffit, 1991; Proffit et al., 2012; Jakobsone et al., 2011). Surgical interventions are invasive and can lead to complications. Table 4

represents the most common complications associated with the maxillary and mandibular orthognathic surgical procedures.

The advent of rigid fixation has greatly improved the patient comfort and stability of the surgical procedures. With rigid fixation, immobalization of the jaws have become unnecessary and the combination of maxillary advancement and mandibular setback is acceptably stable in terms of relapse (Van Sickels, 1996). Other surgical technique which can be utilized in cases of hypoplastic maxilla is distraction osteogenesis. It is based on stretching of an osteotomized area to form additional bone and soft tissue (Crago, 2003). It is performed in growing class III patients with maxillary dysplasia usually associated with syndromes (Figueroa, 1999). Greater movement can be performed with distraction osteogenesis but precise and pre-planned movement is not possible which can be routinely done with orthognathic surgical procedures (Ngan, 2015). Much recently, surgery-first approach (SFA) is being promoted which performs directly an orthognathic surgery, skipping the pre-surgical orthodontic preparation (Sharma et al., 2015). SFA treat facial aesthetics first and then occlusion, whereas the opposite happens in conventional orthognathic surgical procedures. Treating the occlusion first as in conventional approach takes a long time and is hardly appreciated by the patient. SFA has a short preparation period, immediate results, psychosocial benefits, rapid creation of favourable environment for orthodontic tooth movement, overall shorter treatment duration and satisfaction rates high for both the orthodontist and the patient. Prediction of final occlusion is the biggest disadvantage of SFA due to non-coordination between the two arches. Other disadvantages include the difficulty of treating extraction cases, planning is time consuming, require high expertise, patient selection is critical, greater surgical movements are required and constant communication between the surgeon and orthodontist is required (Peiro-Guijarro et al., 2016).

**Digital diagnosis and treatment planning:**

Recently breakthroughs in three-dimensional imaging have made an enormous leap in the diagnosis and management of surgical treatment of class III malocclusions. Computed tomography (CT) imaging, especially cone-beam computed tomography (CBCT) is used for 3D reconstruction of hard tissues of the face with an added advantage of reduced radiation dose and scanning time (De Vos et al., 2009). 3D laser or 3D photogrammetery can be used for surface image acquisition of soft tissue structures of the face (Lane, 2008). Surgical planning software can be used to process these images, perform cephalometric analysis, reposition osteotomy segments as per the treatment plan, observe the soft-tissue effect on a surgical procedure, inform and educate the patient regarding the results (Xia et al., 2005). Computer aided design (CAD), computer aided manufacturing (CAM) and rapid prototyping (RP) are useful in the fabrication of surgical wafer used in orthognathic surgery (Azari, 2009). Rapid prototyping or stereolithography in particular is being used to create 3D models to accurately plan surgical procedures and achieve better post-operative surgical results (Gateno et al., 2003). Surgical splints and guides can also be fabricated using RP (Seres et al., 2014). Use of surgical planning software increases the predictability of the surgery, reduces the surgical complications and post-surgical morbidity (Centenero, 2012). According to Wrzosek et al., time required for treatment planning in orthognathic surgical cases is reduced by 91% in comparison to conventional orthognathic surgical planning (Wrzosek et al., 2016) This 3D-software can also be used for real-time navigation of hard and soft tissue structures during an intra-operative orthognathic surgical procedure (Sun et al., 2014).

Other digital image analysis methods which have found place in the diagnosis and treatment planning are surface mapping functions and elliptical Fourier descriptors (Gutman et al., 2012; Moon, 1997). They are used to quantify complex three dimensional structures and aid in the planning of complex surgical cases like syndromes and facial asymmetry. The main disadvantage of these newer 3D diagnostic techniques is that they are unaffordable for routine practice and not available easily. Nevertheless, it is important to assimilate them in clinical practice to enhance the treatment outcomes.

**Table 1:-** Favourable or positive factors for treating class III malocclusion by orthodontic camouflage or orthognathic surgery.

| Orthodontic camouflage | Orthognathic surgery |
|---|---|
| Mild anteroposterior skeletal discrepancy | Severe anteroposterior skeletal discrepancy |
| Moderate anteroposterior skeletal discrepancy (extraction approach) | ANB <-4 degrees |
| Functional CO-CR discrepancy | Maxillary/mandibular ratio of 84% |
| Deepbite | IMPA 83 degrees |
| Low mandibular plane angle | Holdaway angle of 3.5 degrees |
| Wits <-5 mm | Wits >-5 mm |

**Table 2:-** Guidelines for selecting the extraction pattern based on the characteristics of the case.

| Extraction pattern | Indication |
|---|---|
| Only manibular premolars | When only lingual tipping of lower incisors is required without moving the upper incisors |
| Maxillary second premolars<br>Mandibular first premolars | When there is not much crowding in upper arch and mesial movement of maxillary molar is required to correct the molar relationship |
| Maxillary first premolars<br>Mandibular first premolars | When there is crowding in upper and lower arch with molar relationship being almost in class I |
| Mandibular incisor | Mild crowding in lower arch<br>Anterior crossbite or edge-to-edge incisor relationship |

**Table 3:-** Indication and ideal site of placement of microimplants in the treatment of class III malocclusion.

| Site of placement | | Indication |
|---|---|---|
| Mandible | Retomolar area (Best site) | Retraction and distalization of the mandibular dentition<br><br>Uprighting the mandibular arch |
| | Interradicular space between mandibular first molar and second premolar | Retraction of the mandibular dentition |
| | Interradicular space between mandibular first molar and second molar | |
| Maxilla | Interradicular space between maxillary first molar and second premolar to provide absolute anchorage for class III elastics | High angle skeletal class III malocclusion with open bite |
| | Interradicular space between maxillary first premolar and canine or second premolar | En-masse protraction of the maxillary dentition |
| | Anterior palate | Protraction of the anterior maxilla |

**Table 4:-** Most common complications with the maxillary and mandibular orthognathic surgery.

| Maxillary Surgery | Mandibular surgery |
|---|---|
| Nausea or vomiting, Extensive bleeding, Infection, Ischemia | Neurosensory deficit (anesthesia or paresthesia) |
| Deviated nasal septum | Post-operative infections |
| Unfavourable split, Insufficient fixation | Bone fracture |
| Early relapse or post-healing relapse | Unfavourable split, Delayed healing or non-healing |
| Over-impaction of the maxilla | Temporomandibular dysfunction and pain |
| Sinus complications like improper drainage, headaches, congestion etc. | Limitation in range of motion |
| Decreased masticatory efficiency | Decreased masticatory efficiency |
| Gingival recession, bone loss or periodontal damage | Gingival recession, bone loss or periodontal damage |
| Loss of pulp vitality | Compromised airway |
| Patient dissatisfaction with the aesthetic result | Patient dissatisfaction with the aesthetic result |

## Conclusion:-

Class III malocclusions have a wide range in the population due to the conglomeration of various races, ethnic groups and community. Class III malocclusions are effortless to notice, straightforward to diagnose but challenging to treat and demanding to retain. The advent of newer three dimensional digital techniques have made the diagnosis and treatment planning of class III malocclusion more easy, precise and accurate. The treatment of class III malocclusion depends on the age and growth stage of the patient when they attend to correct their problem.

Following conclusions can be drawn:

1. The pattern of Class III malocclusion is determined very early in life and it is clinically difficult to control the class III tendency of growth until complete cessation of growth has occurred.
2. Various growth modification appliances are available in the literature at present, but there is a wide variation in the long term stability and outcome of these treatment approaches.
3. Best time for interceptive treatment using facemask is in the deciduous or early-mixed dentition stages, preferably under the age of 10 years.
4. Chin-cup if used as a treatment modality should be continued to be worn until the age of 18 years to maintain the treatment effects.
5. Functional appliances can be used to create a favourable environment for growth in class III patients, but there are minimal orthopaedic/skeletal changes. They are recommended to be used as retainers after class III corrections.
6. Removable and uncomplicated fixed appliances can be used to treat cases of simple anterior dental crossbites.
7. Use of BAMP, skeletal anchorage systems and mini-implants has widened the purview of orthopaedic skeletal changes circumventing the undesirable dentoalveolar effects.
8. True class III malocclusion with severe skeletal discrepancy and non-growing status are best treated with combined orthodontic and orthognathic surgical approaches.
9. SFA is recommended in class III surgical cases which fall in the ambit of its indication.

The rise and upsurge on the use of three dimensional imaging software for diagnosis and treatment planning is imminent and the future of orthognathic surgeries relies on it.

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