Effectiveness of Management of Skeletal Class III Malocclusion during Primary, Mixed, and Permanent Dentition Period – A Literature Review

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Abstract

Skeletal class III malocclusion is one of the most challenging conditions in clinical dental practice. Various treatment options are available for the management of the condition such as reverse twin block appliance, facemask appliance, chin cup therapy, bone anchorage maxillary protraction device, and tandem traction bow appliance. However, treatment timing is controversial. There are various advantages and disadvantages following the correction of skeletal class III malocclusion during primary, mixed and permanent dentition period. Hence, this review aims to compile the available literature regarding the effectiveness of correction of skeletal class III malocclusion during primary, mixed, and permanent dentition.

Keywords

- class III malocclusion
- reverse twin block appliance
- treatment timing

Introduction

Skeletal class III malocclusion is characterized by maxillary deficiency, mandibular prognathism, and combinations of the above. A wide range of etiological factors are associated with the condition that includes genetic and environmental factors. Heredity and genetic contribution seem to have a very strong influence, especially in case of mandibular prognathism.[1] Suzuki reported paternal class III to be more influencing than maternal condition.[2] One of the major factors to be considered for treating skeletal class III malocclusion is the treatment timing.[3] Growth is an ongoing process and redirection of unfavorable growth in the right direction can lead to successful outcome. Timing of intervention is of utmost importance and is one of the most controversial topic. Advantages of early management are patient compliance, improvement in the quality of life, psychological benefits, redirection of unfavorable growth, and successful maxillary protraction. However, some of the major disadvantages are longer retention period and higher incidence of relapse due to mandibular growth. Late treatment has benefits such as utilization of pubertal growth spurt, increase in growth hormone, and physiological changes of the body. However, in some cases, class III conditions can worsen when not interfered early. Treatment during adulthood will leave us with no options, other than surgical correction or camouflage. Hence, there are different schools of thought regarding the treatment timing for the management of skeletal class III malocclusion. Controversy regarding early and late correction of class III malocclusion is significant in the literature. Types of dentitions are also one of the factors to be considered for managing the condition. No literature so far has discussed the treatment timing for class III malocclusion emphasizing the types of dentitions. Hence, this review aims to discuss the effectiveness of correction of skeletal class III malocclusion in primary, mixed and permanent dentition period using various appliances such as reverse twin block, facemask, Frankel III, tandem

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traction bow appliance (TTBA), chin cup, and bone anchorage maxillary protraction devices. Various studies done using reverse twin block, facemask, Frankel III, TTBA, chin cup, and facemask appliance in the age group of 5 to 13 years have been included in the study.

Discussion

Age-Related Changes in the Growth of Maxilla and Mandible

Postnatal growth of the maxilla occurs by apposition of bone at the sutures, which connects the maxilla to the cranial base and surface remodeling. Maxilla grows downward and forward up to the age of 6 by forward displacement of maxilla from cranial base. At 7 years of age, cranial base growth stops and sutural growth begins, bringing the maxilla forward.

The maxillary prominence angle decreases progressively throughout childhood and increases after adolescence. The intersphenoidal synchondrosis ossifies immediately before birth and the ethmoidal synchondrosis ossifies 7 years after birth, the growth of the central area of the cranium completes in the early stages of life.[4]

At birth, the transverse and anteroposterior diameters of the bone are much greater than the vertical. The frontal process is well-marked and the body of the bone consists of little more than the alveolar process. The teeth sockets reach almost to the floor of the orbit. The maxillary sinus presents the appearance of a furrow on the lateral wall of the nose. In the adulthood, the vertical diameter is the greatest and no much changes occur. In old age, the bone reverts in some measure to the infantile condition as its height is diminished. After the loss of the teeth, the alveolar process is absorbed and the lower part of the bone is contracted and reduced in thickness.

The steady growth of maxilla is seen until 5 years of age, where 85% of adult size is achieved. Page reported that at the age of 8, up to 90% of maxillary growth is attained.[5] Anteroposterior palatal growth occurs around 7 years of age. Vault depth is also attained by 7 years of age. Post 8 years of age, the decline in growth is seen that completes by approximately 11 years of age. Minimal growth changes in the maxilla are seen following 11 years of age. This is one of the major factors to be considered for maxillary protraction. The closure of midpalatal suture usually occurs at a certain age, that is, 11 to 13 years in girls and 14 to 16 years in boys. Fusion of maxillary sutures is completed at the age of 14 to 15 in females and 15 to 16 in males.[6]

Growth of the mandible occurs by endochondral growth mechanism at each end and intramembranous growth between the bones. The body of the mandible grows by periosteal apposition of bone on the posterior surface of the ramus. Ramus grows higher by endochondral replacement at condyle accompanied by surface remodeling.

The condyle is the primary growth center that contributes to the growth of the mandible. The condylar cartilage is capable of regional adaptive growth. Buschang et al reported that maximum growth in the condylar region is seen during the pubertal period as compared with prepubertal period.[6] Decrease in condylar growth occurs during early childhood. Growth of the mandible continues up to 16 to 20 years, followed by which there is a decline. At birth, the body of the bone is a mere shell, containing the sockets of the two incisors, the canine, and the two deciduous molar teeth, imperfectly partitioned off from one another. The mandibular canal is of large size, and runs near the lower border of the bone; the mental foramen opens beneath the socket of the first deciduous molar tooth. The angle is obtuse (175 degrees), and the condyloid portion is nearly in line with the body. The coronoid process is of comparatively large size, and projects above the level of the condyle. During childhood, the two segments of the bone become joined at the symphysis, from below upward, in the first year; but a trace of separation may be visible in the beginning of the second year, near the alveolar margin. The body becomes elongated in its whole length, but more especially behind the mental foramen, to provide space for the three additional teeth developed in this part. The depth of the body increases owing to increased growth of the alveolar part, to afford room for the roots of the teeth. The angle becomes less obtuse, owing to the separation of the jaws by the teeth; about the fourth year it is 140 degrees. During adulthood, after the eruption of permanent teeth the mental foramen lies midway between the upper and lower borders of the bone. Growth of the rami takes place posteriorly and vertically by the process of remodeling. Posterior growth accommodates the eruption of permanent molars and reduces the angle of mandible to almost 110 to 115 degrees. Vertical growth allows the condylar process to lie higher than the coronoid process. During old age, teeth fall out and the alveolar border is absorbed so that the height of the body is markedly reduced. The mental foramen and the mandibular canal are close to the alveolar border. The angle again becomes obtuse approximately 140 degrees because the ramus is oblique. Mandibular growth was found to be statistically significant for the age periods of 16 to 18 years and 18 to 20 years. Growth from 16 to 18 years was greater than that from 18 to 20 years. Mandibular growth was found to involve an upward and forward rotation, a result of posterior vertical growth exceeding anterior vertical growth.[7] Hence, mandibular growth continues for a longer period even if the treatment is initiated during an early age.[8]

Management of Skeletal Class III Malocclusion During

Primary Dentition Period

Intervention at an early stage, such as the primary dentition period, has been recommended by various authors[9,10] The goals of early intervention are to prevent progressive, irreversible soft-tissue or bony changes, improve skeletal discrepancies, provide a favorable environment for normal growth, improve occlusal function, enhance and shorten phase II comprehensive treatment, and provide pleasing facial aesthetic, thus improving the psychosocial development of the child.[11]

Turpin et al have reported positive and negative factors for early correction of skeletal class III malocclusion.[12]

TURPIN et al (1981)	
Positive factors:	Negative factors:
1. Good facial esthetics	1. Poor facial esthetics
2. Mild skeletal disharmony	2. Severe skeletal disharmony
3. No familial prognathism	3. Growth complete
4. Anterior posterior functional shift	
5. Convergent facial types	

Proclination of mandibular incisors and retroclination of maxillary incisors result in anterior posture of mandible due to incisal interferences. This condition is called pseudoclass III malocclusion. Forward positioning of mandible can express the genes associated with mandibular prognathism, leading to true skeletal class III malocclusion. This is one of the major concerns in deciduous dentition. When such conditions are identified during primary dentition, treatment must be initiated to prevent worsening of the condition.[13,14] Guyer et al stated that in children with anterior crossbite and reverse deep bite, intervention during primary dentition is beneficial.[15]

According to Ngan et al, promising results can be achieved for maxillary retrusion at an early age, if untreated can worsen later. However, mandibular excess or vertical excess are poor candidates for early treatment as peak mandibular growth occurs during pubertal period. Relapse of such conditions is also high during prepubertal or pubertal period.[16]

Sargod et al, in his case report, used reverse twin block appliance in two children in the age group of 5 years and achieved positive results. He stated that it is important to remove the interlocking of the anterior teeth for unrestricted growth of maxilla and to guide the mandible to the correct position.[17]

Sadia et al conducted a study, in which she compared the use of facemask therapy in 3 to 6, 6 to 9, and 9 to 12 age group, better results were seen in the age group of 3 to 6 years.[18]

Kapust et al compared the treatment effect of facemask appliance in various age groups and concluded that the effect was much better in the age group of 4 to 7 years.[19] Franchi et al, in his study, stated that when treatment is initiated with facemask appliance, maximum results are seen during early or mixed dentition period.[20] Bedolla-Gaxiola et al conducted a study, where she used facemask appliance during primary dentition period (5 years), acceptable results were achieved.[21]

Hence, in case of maxillary retrusion acceptable results can be achieved during primary dentition period using appliances such as facemask. Early treatment is beneficial for maxillary protraction and palatal expansion considering the age at which maxillary growth occurs.

Early treatment can also decrease the psychological burden in these children.

Habits, position of the mandible, and abnormal muscular forces can be prevented when treatment is initiated during primary dentition period as compared with mixed or permanent dentition period.

Chin cup therapy has been advised in the age group of 4 to 14 years.[22,23] Sakamoto , in his study used chin cup appliance in the age group of 3 to 12 years, concluded stating that the treatment effect was much higher in younger age group.[24]

However, conflicting results are stated by various authors in case of mandibular prognathism. Some authors believed in two to three phases of treatment, in which mandibular prognathism is corrected during the second or third phase.

Regarding the skeletal changes during deciduous dentition, authors have reported conflicting results. According to a study done by Kajiyama et al, increased skeletal changes are seen during primary dentition period as compared with mixed dentition period.[25] But Kapust et al have reported less orthopaedic changes seen in younger age group as compared with older age group.[19] Gnanashanmugam and Kannan stated that currently there are no evidence present to suggest the reduction or elimination of future treatment following early management of class III malocclusion.[26]

Sl. no.	Title of the study	Age	Parameters	Results
1.	Early class III management in deciduous dentition using reverse twin block[17]	5 years	Case 1: overjet, profile	Case 1: Improvement in profile, positive overjet was achieved, anterior crossbite was corrected
2.	Sagittal changes after maxillary protraction with expansion in class III patients in the primary, mixed, and late mixed dentitions: a longitudinal retrospective study[18]	Group 1: 3–6 Group 2: 6–9 Group 3: 9–12	SNA, SNB, maxillary depth, facial convexity angle	Greater significant changes were seen in patients treated in the primary and mixed dentition phases. Females showed highly significant changes in most linear and angular measurements between the ages of 3 and 6 years ($p < 0.0001$) compared with males ($p < 0.05$) at the same age. Significant changes were seen in the angle between the anterior part of the maxilla and the base of

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Sl. no.	Title of the study	Age	Parameters	Results
				the skull (SNA), the maxillary depth, and the facial convexity angles, being more active in females than males. In contrast, the angle between the anterior part of the mandible and the base of the skull (SNB) showed no significant changes in all age groups, with the exception of males between 3 and 6 years
3.	Cephalometric effects of facemask/expansion therapy in class III children: a comparison of three age groups[19]	4–13 years	Skeletal, dental and soft tissue analysis	Skeletal change was primarily a result of anterior and vertical movement of the maxillae. Mandibular position was directed in a downward and backward vector and soft tissue effects resulted in a more convex profile. Greater differences were observed in apical base change (ABCH) and total molar correction (6/6) in the younger age groups
4.	Quick correction of a skeletal class III malocclusion in primary dentition with facemask plus rapid maxillary expansion therapy[20]	5 years	Overjet, SNA, SNB, articulare, saddle, gonial angle	Clockwise rotation of the mandible, a positive overjet of 3 mm, a correct overbite, a canine Class I relationship, and a bilateral flush terminal plane
5.	Effective timing for the application of orthopedic force in the skeletal class III malocclusion[21]	3–12 years	A-B difference, crossbite	Correction of crossbite was achieved. The final values showed more improvement in the younger age group in the group with milder disharmony before treatment

Mixed Dentition Period

The transition from deciduous to mixed dentition period occurs at the age of around 6 years when the permanent lower central incisor erupts. First phase of transition occurs when the incisors and molars erupt to the cavity, termed as early mixed dentition period at the age of 7 to 10 years. The second transition period occurs when the canine, premolars, and second molars erupt, which is termed as late mixed dentition period around the age of 11 to 12 years. Significant changes occur in the craniofacial region during this transition period that can be utilized for orthodontic therapy. Hence, we can divide the management of class III malocclusion in the mixed dentition period to early and late mixed dentition period.

Early Mixed Dentition Period

Ideal age for maxillary protraction as mentioned by various authors is during the early mixed dentition period. This is because the main aim of appliances such as facemask is to enhance forward displacement of maxilla by sutural growth. Melsen and Melsen in her histological study reported that the mid palatine suture is broad and smooth during infantile period (8–10 years), which then become squamous and overlapping during late adolescent period. Treatment initiated before the age of 8, after eruption of central incisors, is the most appropriate time as the sutures are broad and flat.[27] Therapy induced during early mixed dentition is reported to show more favorable skeletal changes as compared with late mixed dentition period.

Baccetti et al conducted a study where facemask appliance was used in two groups, early and late mixed dentition period. Result showed that the treatment initiated during early mixed dentition period showed better result as compared with late mixed dentition period. More upward and forward direction of condylar growth was seen in early mixed dentition group.[28] In another study, he reported more favorable changes in the craniofacial skeleton seen in early mixed dentition compared with late mixed dentition.[20]

Franchi et al reported significant favorable changes in early mixed dentition stage as compared with late mixed dentition stage. Favorable postpubertal changes were seen in both maxillary and mandibular structures in the early treatment group. In late treatment group, changes were mainly limited to mandible, by restriction of mandibular growth.[29]

Other studies done by Mandall et al, Westwood et al, and Ngan et al also showed significant maxillary protraction during early mixed dentition period.[8,30,31]

According to a systematic review and meta-analysis by Lin et al, maxillary protraction devices during early mixed dentition showed short-term significant skeletal and dental changes; however, during long-term follow-up, relapse of some skeletal and dental parameters was noted. Hence, long-term study is required for a definitive conclusion of stability of maxillary protraction.[32]

Sharma et al reported two cases where significant skeletal changes were achieved following the use of TTBA in 7-year-old children. He stated that less iatrogenic tooth damage like root resorption, decalcification, and trauma is seen when early treatment is initiated. Several other authors also reported successful outcome following TTBA during early mixed dentition period.[33–35] Atalay and Tortop conducted a study where modified TTBA was used in the early and late treatment group. Significant skeletal and dental changes were seen in both the groups. Maxillary protraction was evidently noticed in both the group; however, reduction in SNB angle was more apparent in the early group as compared with late group[36]

Reverse twin block appliance has been reported to cause mandibular retrusion in early mixed dentition period. Mittal et al in his case report showed successful correction of anterior crossbite in an 8-year-old child.[37] Kidner et al conducted a study in the age group of 7 to 10 years using reverse twin block appliance and concluded that significant changes were seen during early mixed dentition period.[38] However, Shriranjani et al in the systematic review stated that the available evidence for correction of skeletal class III malocclusion using reverse twin block appliance is scarce.[39]

Saveen et al reported acceptable treatment outcome following the use of Frankel III appliance in a 9-year-old child. Restriction of mandibular growth and protraction of maxilla were achieved.[40]

Sugawara et al conducted a study on monozygotic twins; in one child two phase treatment was approached, that is, early correction of crossbite followed by fixed appliance therapy at a later stage; in the other child, single phase treatment was initiated using fixed appliance therapy. There was a significant improvement in the first child; however, during pubertal period relapse was seen with similar profile in both the children. Even though early treatment reduces the intensity of fixed therapy at the later stage, no much differences were seen during pubertal period.[41]

Al-Khalifa et al reported significant effect following the use of chin cup in the age group of 7 to 9 years.[42]

Study conducted by Alarcón et al in the age group of 8.5 years using chin cup appliance concluded stating wide modification of the mandibular shape (more rectangular mandibular configuration, forward condyle orientation, gonial area compression, and symphysis narrowing).[43]

Deguchi and McNamara conducted a study in 9-year-old children, reporting reduction in mandibular growth increments following chin cup appliance therapy.[44]

Akin et al, Lin et al, Y.L et al showed similar positive results following chin cup therapy. Majority of the studies done on chin cup appliance are during mixed dentition period.[45–47]

Ideal age group for appliances such as chin cup, which restrict the growth of mandible, was reported to be before 8 years of age.

Sl. no.	Title of the study	Age	Parameters	Results
1.	Treatment and post-treatment craniofacial changes after rapid maxillary expansion and facemask therapy[20]	Group 1: Early mixed dentition period Group 2: Late mixed dentition period	Linear measurement for the assessment of sagittal relationship, mandibular dimension, angular measurement for cranial base angle, angular measurement to assess condylar angulation	Significant increase in the sagittal growth of maxilla can be obtained at when treatment is performed at early mixed dentition period Backward rotation of mandible with increase in anterior facial height is seen when the treatment is initiated during late mixed dentition period Class III malocclusion in the early mixed dentition appears to induce more favorable overall craniofacial changes than treatment in the late mixed dentition
2.	Skeletal effects of early treatment of class III malocclusion with maxillary expansion and facemask therapy[28]	Group 1: Early mixed dentition period Group 2: Late mixed dentition period	Linear measurement for the assessment of sagittal relationship, mandibular dimension, angular measurement for cranial base angle, angular measurement to assess condylar angulation	Maxillary expansion and facemask therapy was more effective in early mixed dentition period. Significant maxillary protraction was seen in early mixed dentition period. Smaller increments in total mandibular length associated with more upward and forward direction of condylar growth were recorded only in the early-treatment group
3.	Postpubertal assessment of treatment timing for maxillary expansion and protraction therapy followed by fixed appliances[29]	Group 1: Early mixed dentition period Group 2: Late mixed dentition period	Skeletal changes, maxillary dental, mandibular dental, and interdental changes	Orthopaedic treatment of class III malocclusion was more effective when it was initiated at an early developmental phase of the dentition rather than during later stages Early treatment produced significant favorable postpubertal modifications in both maxillary and mandibular structures, whereas late treatment induced only a significant restriction of mandibular growth

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Sl. no.	Title of the study	Age	Parameters	Results
4.	Stability of maxillary protraction therapy in children with class III malocclusion: a systematic review and meta-analysis[32]		SNA, SNB, ANB, mandibular plane angle, overjet, and lower incisor angle	Maxillary protraction can be a short-term effective therapy and might improve sagittal skeletal and dental relationships in the medium term. But some skeletal and dental variables showed significant relapse during the follow-up period. Long-term studies are still required to further evaluate its skeletal benefits
5.	Early treatment of class III malocclusion with modified tandem traction bow appliance and a brief literature review[33]	7 years	SNA, SNB, ANB, Wits appraisal, midfacial length, mandibular length, maxillomandibular, differential, Steiners analysis, IMPA, interincisal angle, Y axis	The correction in the cross bite was achieved in six to seven months Children's compliance and acceptance for the appliance was good. Follow-up of 2 years and 1 year showed no relapse
6.	Dentofacial effects of a modified tandem traction bow appliance[36]	Group 1: Early treatment (8 years) Group 2: Late treatment (11 years)	Skeletal, dental analysis (Linear and angular measurements)	Maxillary protraction was evidently noticed in both the group; however, reduction in SNB angle was more apparent in the early group as compared with late group
7.	Reverse twin block for interceptive management of developing class III malocclusion[37]	Case report1: 11 years Case report 2: 8 years	SNA, SNB, ANB, SND, Witts appraisal, SN-MP, UAFH, LAFH, U1-SN, IMPA, mandibular length	Anterior crossbite was corrected, and there was a marked improvement in facial appearance of the children. RTB can be a viable and effective functional appliance treatment modality for early management of developing class III malocclusion
9.	Craniofacial adaptations induced by chin cup therapy in class III patients[44]	9 years	Investigation of the orthopaedic effect of CC in the posterior displacement of the mandible and the glenoid fossa.	Significantly decreased gonial angle, less incremental increase in mandibular length (Gn-Cd), posterior movement of points B and Pg, not increased anterior facial height

IAMP, Incisor Mandibular Plane Angle; LAFH, Lower Anterior Facial Height; SN-MP, Sella Nasion-Mandibular Plane Angle; RTB, Reverse Twin Block; UAFH, Upper Anterior Facial Height.

Late Mixed Dentition Period

Treatment effect of skeletal class III malocclusion during late mixed dentition period is a controversial topic. Most of the authors recommend treatment during early mixed dentition rather than late mixed dentition period. However, there are studies stating the positive effect of class III treatment even during late mixed dentition period.

Battagel and Orton reported that positive results can be achieved following facemask therapy in late mixed dentition period with minimum 2 years of retention. Mandibular growth was redirected, but not reduced during the treatment. Post retention growth acceleration can be minimized following facemask therapy during late mixed dentition period.[48]

In a case report by Pattanaik and Mishra, a 12-year-old female child was treated with facemask and rapid maxillary expansion device. Acceptable results were achieved.[49]

Even though facemask has been indicated during deciduous or early mixed dentition period, positive results can be achieved even during late mixed dentition period.

Rajasekaran and Abdulla used Frankel III appliance in an 11-year-old girl; optimum results were achieved in a follow-up period of approximately 2 years.[50]

Fareen et al conducted a study in which a combination of reverse twin block appliance and reverse pull facemask was used in early and late mixed dentition group. Significant changes were seen in both the group; however, more favorable craniofacial changes were seen particularly in late mixed dentition group.[51]

Singh et al used chin cup therapy during late mixed dentition period and redirected mandibular growth was achieved.[52]

Maxillary protraction using bone anchorage and class III elastics is reported to be more effective during late mixed and permanent dentition period.[53]

Van Hevele et al conducted a study on 218 patients with mean age of 11.4 years using bone anchorage maxillary protraction device (BAMP). He reported a success rate of approximately 93.6%.[54]

Use of BAMP during late mixed dentition period was supported by various authors.[55,56]

Feng et al in a systematic review titled, effectiveness of TAD anchored maxillary protraction in late mixed dentition period, concluded stating that TAD anchored maxillary protraction has greater protraction effect.[57]

Barrett et al in his study used chin cup appliance and reported limited class III correction with light force chin cup (fewer than 50% of the patients) mostly by dentoalveolar (uprighting of mandibular incisors) rather than orthopaedic changes during early mixed dentition period.[22]

Sl. no.	Title of the study	Age	Parameters	Results
1.	Class III malocclusion: the post-retention findings following a non-extraction treatment approach[48]	12.9 years	Skeletal, dental, soft tissue analysis	Overjet correction was achieved by a combination of upper and lower incisor movement with no alteration in overbite. This was accompanied by a downward and backward repositioning of the mandible, redirecting, rather than restricting mandibular growth
2.	Treatment of Class III with facemask therapy[49]	12 years	Sagittal, dentoalveolar, and vertical cephalometric measurements	The patient displayed a bilateral Class I canine and a Class I molar relationship. The SNA angle had increased while SNB decreased resulting in a normal jaw relationship (ANB = 2 degrees) Normal overbite (1 mm) and overjet (3 mm) were achieved, and the midlines were centered. Vertical skeletal measurements remained near-constant
3.	Interception of skeletal Class 3 malocclusion with Frankle 3 appliance in late Mixed dentition: a case report[50]	11 years	Skeletal and dental analysis	This study demonstrated the achievement of optimal results, and the stability of the correction of a functional Class III malocclusion treated with a Frankle 3 and followed by corrective orthodontics
4.	Treatment effects of reverse twin-block and reverse pull facemask on craniofacial morphology in early and late mixed dentition children[51]	Early mixed dentition: 8–9 years Late mixed dentition: 10 -11 years	Ricketts analysis	RPFM revealed more favorable craniofacial changes than RTB, particularly in the late mixed dentition stag
5.	Bone-anchored maxillary protraction to correct a class III skeletal relationship: a multicenter retrospective analysis of 218 patients[54]	11.4 years	SNA, SNB, ANB, Wits analysis	Miniplate failure was six times higher in the maxilla and occurred more in younger patients
6.	Treatment effects of the light-force chincup[22]	8 years	Skeletal, dental analysis (linear and angular measurements)	Fewer than 50% of the subjects treated with the chin cup had favorable clinical outcomes. Correction of the initial Class III malocclusion occurred through significant dentoalveolar changes. The light-force chin cup did not produce orthopaedic changes in the mandible.

Permanent Dentition Period

Maxillary protraction devices are less effective during permanent dentition period as compared with primary and mixed dentition period.

However, some authors have reported cases with acceptable results during prepubertal period.

Jackson and Kravitz al used facemask appliance with maxillary expansion to correct skeletal class III malocclusion in an adult patient, skeletal change as a result of anterior and vertical movement of the maxilla, significant changes in mandibular position, and downward and backward movement of the chin was noted. However, there was increase in vertical dimension of the face.[58]

Jatol-Tekade et al used TTBA in a 12-year-old child; optimal outcomes were achieved.[59]

In a case report by Singh et al, a 12-year-old girl with permanent dentition was treated using reverse twin block and fixed mechanotherapy with a 3-year follow-up period. Favorable environment for unrestricted growth of maxilla, at the same time redirecting mandible to a clockwise rotation along with correction of incisal relationship, was achieved.[60]

Bone anchorage maxillary protraction can be used during permanent dentition period. Successful outcomes have been achieved by using this appliance.

According to Cordasco et al, miniplate placement on the anterior surface of the maxilla is invasive and bone maturity is not adequate until around age 11; hence, it can be used during permanent dentition period.[61]

In a study by Kuroda et al, extraction of four premolars, rapid palatal expansion, and combination occipital and vertical-pull chin cup over a 2-year period led to good results at age 16, with minimal dental or skeletal relapse at age 18 years, 5 months.[62] In adulthood, not much treatment options are present, other than surgical intervention and camouflage treatment.

Sl. no.	Title of the study	Age	Parameters	Results
1.	Expansion/facemask treatment of an adult class III malocclusion[58]	19 years	Skeletal and dental cephalometric measurements	Skeletal change was primarily a result of anterior and vertical movement of the maxilla Significant changes in mandibular position also contributed to the class III correction
2.	Skeletal class III correction in permanent dentition using reverse twin block appliance and fixed mechanotherapy[60]	12 years	Skeletal and dental cephalometric measurements	Redirected the mandibular growth to a clockwise direction Corrected the incisal relationship
3.	Chincup therapy for a young woman with anterior displacement and obtuse angle of the mandible in Class I malocclusion[62]	16 years	Skeletal cephalometric analysis of maxilla, mandible and cranial base	Closure of the gonial angle that induced backward rotation of the mandible

Conclusion

Management of skeletal class III malocclusion is still a controversial topic, especially the treatment timing.

According to Campbell, goals of early interception of class III malocclusions are as follows:

1. help provide a more favorable environment for normal growth
2. achieve as much relative maxillary advancement as possible
3. To improve occlusal relationships
4. To improve facial esthetics for more normal psychosocial development[63]

Treatment timing is debatable as each group has its own benefits and drawbacks.

Accurate diagnosis and understanding of the individual growth pattern are very important in determining the proper timing of class III treatment.

Optimal treatment timing for facemask therapy is in the deciduous or early mixed dentition period.

Delaying appropriate treatment beyond the mixed dentition stage (10 years of age) will limit the effectiveness of orthopaedic correction.

More importantly, treating a class III malocclusion in the late deciduous and early mixed dentition stages has been shown to be more beneficial to the child as there is improved maxillary orthopaedic correction combined with controlled mandibular growth than when treatment is undertaken in the later childhood growth stages using reverse twin block appliance.[17]

However, in case of BAMP, treatment is indicated to begin once bone maturity is attained, which is during the late mixed or permanent dentition period.[18]

Chin cup therapy is primarily used to restrict the growth of mandible; majority of the studies support the use of chin cup during early mixed dentition period.

Hence, a definite conclusion cannot be attained at the point. More studies with longer follow-up are required to attain a definite conclusion.

Conflict of Interest
None declared.

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