Skeletal and Dentoalveolar Changes Using Removable and Fixed Functional Appliances in Class II Malocclusion

Sukanya Arya[1], Pradeep Raghav[2], Amit Kumar Khera[3], Sajal Gupta[4],Ushmita Mehta[5]

[1,2,3,4,5] *Swami VivekanadSubharti University, Department of Orthodontics and Dentofacial Orthopedics, Meerut, Uttar Pradesh*

[1]sukanya.arya01@gmail.com, [2]drpradeepraghav@gmail.com', [3]amitkhera@rediffmail.com, [4]sajalgupta0004@gmail.com, [5]ushmitamehta97@gmail.com

***Abstract*—The prevalence of Class II malocclusion is common inorthodontic practice. Functional appliance therapy has become a generally accepted method to treat severe and moderate discrepancies of sagittal jaw relations in children. A variety ofdifferent functional appliances are available but their selection is of prime importance. The efficacy of functional appliances and changes produced by their application are still the subject of controversy. Functional appliances encompass a range of removable and fixed devices that are designed to create three-dimensional changes in the dentition and development of the jaws. This literature review attempts to summarize the skeletal and dentoalveolar changes produced by different functional appliances in Class II malocclusion with the help of recent databases (2000-2021).**

***Keywords* —Class II malocclusion, functional appliances, fixed functional appliances, removable functional appliances, dentoalveolar effects.**

I. Introduction

The prevalence of Class II malocclusion is common in orthodontic practice. Mc Namara[1] reported mandibular retrusion as the most common characteristic of class II malocclusion. Class II division 1 malocclusions with mandibular deficiency have been treated with different type of functional appliances.

Functional appliances have been used for over a century in themanagement of Class II malocclusion being proven to produce acombination of skeletal and dental effects during the treatment phaseto effectively reduce overjet in growing patients.

A variety offunctional appliances are available that can be broadly categorized intoremovable functional and fixed functional appliances. An importantdiscriminating factor between the fixed functional and removablefunctional appliance is the need for patient compliance.However, the degree of skeletal versus dentoalveolar change thatunderlies these treatment effects is a source of debate.

Despite theirlong history, functional appliances continue to be controversial in theiruse, effectiveness and mode of action. Some researchers haveproposed that the Class II correction observed with functionalappliances was caused by headgear effect by restraining maxillarygrowth.[2,3] While many of the researchers observed that there isstimulation of mandibular growth caused by forward positioning ofmandible.[4,5] Anterior glenoid fossa remodeling and spontaneousanterior mandibular displacement that occurs after elimination of afunctional retrusion also have been cited as contributors to Class IIcorrection.[6,7]So, this review describes the current evidence based on various fixed functional appliances and removable functional appliances and its effects ondentoalveolar and skeletal pattern in Class II malocclusion.

II. Removable Functional Appliances

A. Activator

It is a monoblock appliance which is given in actively growing individual with favourable (horizontal) growth pattern[8]. Ruf[9] showed that there was increase in vertical effective condylar growth and decrease in sagittal effective condylar growth and increase in the vertical development of chin by activator therapy. Basciftci et al[10]showed that ANB angle was decreased and the bite was opened with reduction in overjet. Ramus height, corpus length, anterior and posterior face height all increased significantly. The activator appliance caused maxillary incisor lingual tipping and mandibular incisor labial tipping. The overjet was decreased as a result of the increased forward growth of the mandible and dentoalveolar changes.

B. Bionator

It is an activator derived appliance which enhances normal development. Almeida et al[11,12] evaluated that there was no restriction to maxillary growth along with significant increase in mandibular length (Co-Gn) by with reduction in ANB angle. No significant change was observed in Lower AnteriorFacial Height (LAFH) while posterior face height (S-Go) was increased. Mandibular plane orientation (SN.GoMe) was unaffected while the palatal plane rotated significantly more clockwise. In dentoalveolar structures changes observed were, retroclination of maxillary incisors with proclination of mandibular incisors. The lower molars were extruded significantly morewhile no effect on maxillary molars was seen. It mainly producesdentoalveolar effect with a smaller skeletal effect.[13]

C. Twin Block

Ehsani et al[14]reported that maxilla showed a very minor restriction in growth while the mandible was projected slightly forward with the increase in mandibular and the anterior facial dimensions. “Headgear effect” was seen with twin block appliance as shown by Khan et al[15] this appliance therapy restricts maxillary growth withmaxillary molar distalization. Mills and McCulloch[16] and Baccetti et al[17] attributed most of the overjet reduction to the mandibular skeletal changes.73 percent of overjet correction was due to dentoalveolar changes in whichmolar correction contributed 59 percent. There was increase in mandibular growth with increased proclination of lower incisors, reduction of overjet and correction of molar relation.[18] At the dental level, significant changes were identified with reduction in upper incisor proclination and increase in the lower incisorinclination.

D. Frankel Appliance

There was an improvement of the anteroposterior relationship between the maxilla and the mandible with no restriction to the growth of maxilla while redirecting mandibular growth.[11,19,20]Janson et al[21] suggested that increase in effectivemandibular length is due to an increase in mandibular body lengthrather than increase in ramal height.Retroclination and retrusion of the maxillary incisors, without any forward movement of the maxillary first molars but mesialmovement and extrusion of the mandibular first molars were observedin addition to the skeletal effects of Frankel appliance.[19,20,22]

E. Sander Bite Jumping Appliance

Martina et al[23]reported that BJA did not appear to cause significant maxillary restraint.It produced significant increase in the mandibular length with 51% of the molar relationship correction. It did not have a significant effect on the divergence of the jaws which aids in maximum advancement.Also, the correction of the overjet was due to the increase in mandibular length, to the slight pro-inclination of the lower incisors and the mild retro-inclination of the upper incisors.[24]

III. Comparison Among Removable Functional Appliances

Toth and McNamara[25] reported that Twin Block, as compared to Frankel appliance, produced greater changes in regard to SNB and ANB angles and posterior tipping of the upper incisors. Furthermore, in comparison to Bionator, Twin Block was more effective in the treatment of Class II malocclusion.[18] Most of the studies reported that the Sander Bite Jumping appliance to be the most effective appliance aiming to improve the mandibular length, followed by the Twin Block.[26,27,28] Saima Nizar Hirji et al[29] reported a significant increase in the mandibular length with RFA therapy with an increase in the vertical dimension in a short time using Twin-Block appliance therapy, followed by Bionator appliance therapy. In addition, Frankel appliance treatmenteffects are more skeletal in nature, with better control in the verticaldimension. However, it takes a more extended treatment duration toproduce similar effects.

IV. Fixed Functional Appliances

A. Herbst Appliance

Most of the studies reported that significant amount of Class II correction was achieved by distal bodilymovement and tipping of the maxillary first molars combined with bodilyforward movement of the mandibular first molars.[30,31,32]Fan et al[33]evaluated that the principal skeletal effect of Herbst appliance treatment was due to additional gain at the condyles, which contributes to increase in the sagittal dimension that aids in Class II correction.

B. Mandibular Protraction Appliance

Jena et al[34] reported that 38.50% of the molar correction was contributed by skeletal change due to MPA appliance therapy. Thus, the dentoalveolar changes have major contribution in Class II correction.Siqueira et al[35]reported that increasedpalatal movement of the upper incisors with increased proclinationof lower incisors.

C. Mandibular Anterior Repositioning Appliance(MARA)

Kulbersh et al[36]reported that this appliance restricted the maxillary growth whileno significant contribution to mandibular growth for Class II correction. However, Ardeshna et al[37]reported that maxilla had no significant headgear effect while the maxillary incisor position remained unchanged, whereas the distalization of molar was observed with increase in anterior lower facial height. Thikriat S. Al-Jewair[38]reported that the total mandibular dimensional change was more due tovertical development of mandible rather than the horizontal growth.

D. Functional Mandibular Advancer (FMA)

In a study, it was found that using the FMA in phase 1 therapy that did not incorporate the incisors into the treatment mechanics caused dentoalveolar changes to a lesser extent; thus, the treatment of Class II malocclusion resulted in more pronounced mandibular skeletal changes.[39]The occlusion's improvement in the sagittal dimension wasdue to overjet reduction while molar relationshipimprovement was achieved by a combination ofdental effects (distalization of upper teeth, mesialization of lower teeth)and skeletal effects (mandibular growth stimulation).[40,41]

E. Jasper Jumper

It effectively corrected Class II malocclusion, but the changes were 80% dentoalveolar. The appliance therapy had restrictive effect on the maxilla along with clockwise rotation of the occlusal plane.[42,43]Both the maxillary incisors and molars displayed controlled posterior tipping around their apices. There was significant intrusion of mandibular incisors that occurred with JJ therapy.There wasmild increase in lower anterior facial height with limitation on thevertical development of the maxillary molars; labial tipping and intrusionof the mandibular incisors along with extrusion of mandibular molars.[43]

F. Forsus Nitinol Flat Spring

Karacay et al[44]reported that 66% of the sagittal correction was accounted by dental effects. It was observed that mandibular length wasincreased to a lesser extent with significant posterior rotation in theocclusal plane. The maxillary and mandibular arches were expanded at the front and rear during treatment. It can be activated more on one side than on the other, so it excels at correcting midline deviations.The sagittal occlusal relations wereimproved by approximately 3/4 of a cusp width to the mesial on boththe right and left side as a result of distal movement of the uppermolars and mesial movement of the lower molars. Overjetreduction was found due to retrusion of the upper and protrusion of thelower incisors while intrusion and protrusion of the lower incisorsreduced the overbite. [45,46]

G. Eureka Spring

Stromeyer et al[47] reported that 10% of overjet correction was contributed by skeletal changes while 90% of correction occurred by dental compensation. There was neither an increase in the mandibular plane angle nor in anterior face height is notable. Molar movement was greater in the mandible (60%) than in the maxilla (40%). Change in the occlusal plane was observed as a result of maxillary molar and mandibular incisor intrusion with angular changes in the maxillary and mandibular incisors.

H. Powerscope

There was lengthening of the mandible with no restraining effect on maxilla.[48] Although there were significant skeletal changes but dentoalveolar changescontributed mostly to correction of Class II relation. Kalra et al[49] reported significant changes in skeletal parameters such as forward positioning of the mandible leading to improved Class II jaw base relationship. Also, significant changes were reported in dental parameters such as forward positioning of mandibular incisors, maxillary molar distalization andintrusion with reduction in overbite and overjet respectively.

I. Advansync

It had a continued restraining effect on maxillary growth "headgear effect". Also, this appliance had short-term orthopedic effect on the maxilla and the mandible. It affects the skeletal and dentoalveolar craniofacial complex and are effective in normalizing the Class II malocclusion to Class I in patients treated during the skeletal growth spurt.[50]Al-Jewair et al[51]reported that treatment modalities resulted in reduction in the ANB angle and the angle of convexity and an increase in the anterior and posterior facial height. A significant clockwise rotation of the functional occlusal plane due to proclination of the mandibular incisors while mandibular molars erupted and drifted forward with nonsignificant eruption and distalization of maxillary molars was reported.

V. Comparison Among Fixed Functional Appliances

Rigid fixed functional appliances provide better skeletal results than flexible and hybrid ones.[52]Flexible and hybrid appliances produce greater tooth movement during treatment, in comparison torigid ones as they are not moving the condyle from the mandibular fossa.[53,54]Cozza et al[55]showed that mandibular changes produced by Herbst appliance showed the highest coefficient of efficiency. In a survey study it was evaluated that 51.5% orthodontistsused rigid fixed functional appliances, among them the most preferredwas the Herbst appliance with 72%response followed by Mandibular Anterior Repositioning Appliance(24%) and AdvanSync (4%).[56]

VI. Fixed versus Removable Functional Appliances

The Herbst appliance had the highest coefficient of efficiency (0.28 mm per month) followed by the Twin-block (0.23 mm per month). Both the bionator and the activator had intermediate scores of mandibular growth efficiency (0.17 and 0.12 mm per month, respectively). The Frankel appliancehad the least efficiency (0.09 mm per month).[55] Long term studies, i.e. 5–10 years follow-up, showed that themandible growth appears to return to its earlier pattern after treatmentand the reason for relapse was the changes in tooth position.[57]

In accordance to SN Hirzi et al[58], skeletal corrections achievedwith removable or fixed functional appliances seem to be overall stablein the long term while the dentoalveolar relapse is more frequent.Skeletal corrections, including mandibular elongation, may be achievedif treatment is performed during the pubertal growth phase.

There is little evidence available, concerning the relative effectiveness of fixed and removable functional appliances or in relation to patient experiences and perceptions of these treatment modalities.[59,60]

VII. Summary and Conclusion

- Among the removable functional appliance Sanders Bite Jumping appliance was most effective for improving the mandibular length followed by Twin Block and Bionator. They are mostly associated with excessive vertical bite opening and produce interference with normal functions and mandibular movement,precluding their full-time use.
- Among thefixed functional appliances, rigid fixed functional appliances providebetter skeletal results than flexible and hybrid ones. The most preferred rigid fixed functional appliances are Herbst appliance followed by MARA and AdvanSync.

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