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A comparison of the efficacy of twin block appliance compared with other functional appliances in class II malocclusion patients: A systematic review

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ABSTRACT

The main objective of therapy with twin block (TB) appliance is to induce supplementary lengthening of the mandible by stimulating increased growth at the condylar cartilage. Herein, the study evaluated the efficacy of TB appliance compared with other functional appliances in class II malocclusion patients. Three databases including PubMed, Scopus, and Web of Science were searched until October 2017. The studies were published from 1992 to 2017.Out of 398 studies searched, 25 studies were included and analyzed for the systematic review. The average treatment/observation time was from 5.81 to 16.20 months. The skeletal and soft-tissue variables were compared in TB group with Anderson, Monoblock, Bass, TB + Headger, Herbst, Mini-block, Bionator, Dynamax, Activator, Extra oral maxillary splint, Mandibular protraction appliance, Forsus fatigue resistance device, Bite-Jumping, Xbow, Activator-headgear, and Eruption guidance appliances. Despite two important limitations, the systematic review showed that class II correction in TB appliance therapy was more due to skeletal changes compared with most other appliances. The most ability of TB appliance was on mandibular changes. Also, TB could be suitable treatment in patients with class II malocclusion and therefore using TB appliance in early orthodontic treatment is recommended in these patients.

Keywords: Orthodontic Appliances, Functional, Malocclusion, Angle Class II

1. INTRODUCTION

Class II malocclusions can manifest in various skeletal and dental configurations [1]. Class II division 1 malocclusion can have discrepancies in all three dimensions in the form of narrow maxilla, high palate, and sagittal discrepancy [2]. Functional appliance therapy is a commonly used treatment protocol for growing class II patients [3]. Although fixed functional appliances reduce the need for patient cooperation, they are tooth-borne appliances. On the other hand, removable functional appliances are more tissue borne and they are more likely to produce skeletal changes [4]. Technique of fabrication, construction bites, and hours of wear are important differences in the effects between various orthopedic appliances [5]. Twinblock (TB) appliance is the most preferred functional appliance in UK [6] and in the USA [2]. The main objective of therapy with functional appliances such as TB is to induce supplementary lengthening of the mandible by stimulating increased growth at the condylar cartilage [7].

The aim of this systematic review was the comparison of the efficacy of TB appliance compared with other functional appliances in class II malocclusion patients.

Search strategies and Study criteria

The studies were searched in three databases (PubMed, Scopus, and Web of Science) untilOctober 2017 for publications with English abstract using the keywords of "malocclusion" and "Twin-block". The studies in PubMed were limited to human's articles, and in Web of Science and Scopus were limited to articles.

Study selection

One author (M.S) searched the articles and then the second author (H.R.M) blinded to the first reviewer. If there was any disagreement between two authors, third author (F.R) resolved the problem. All studies were searched for evaluation of the efficacy of TB appliance compared with other functional appliances and only studies with English-language abstract could be included.

Data Extraction

The name of the author, the year of publication, country, the number of participants in each intervention, average treatment/observation time (in months), important conclusions, cephalometric and skeletal variables were extracted from each study. P-value<0.05 was statistically considered as a significant value.

Study characteristics

Out of 398 studies searched in databases after excluding duplication studies, 249 studies were screened (Figure 1). One-hundred and ninety-four studies were not relevant to excluded and also six studies didn't have full-text. Therefore, full-texts of 49 studies were evaluated for eligibility that 29 studies were excluded with reasons. At last, 25 studies were included and analyzed for the systematic review (20 studies had full-text and 5 studies didn't have full-text).

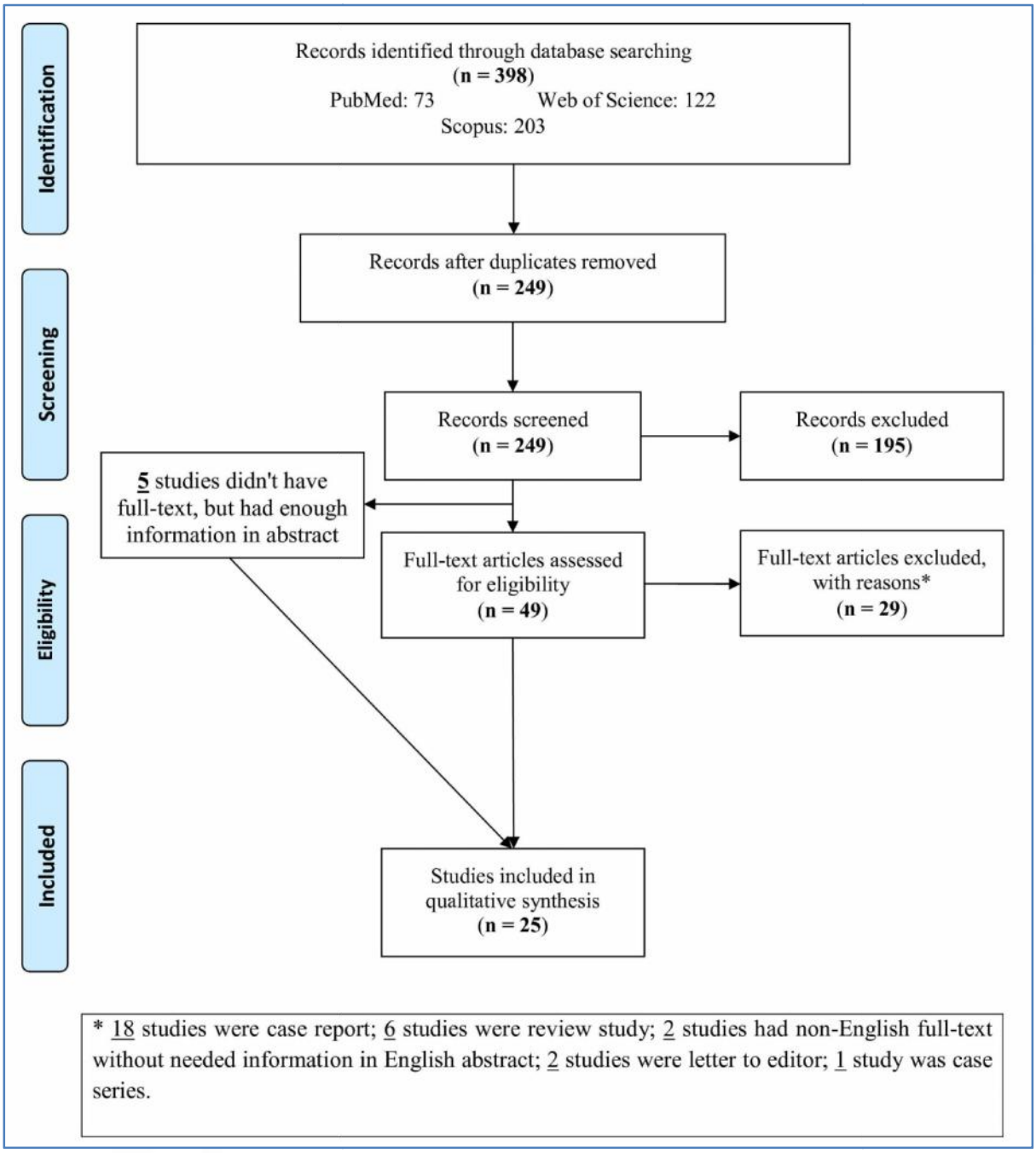

Figure 1 Flowchart of the study

Table 1 shows a number of characteristics of the studies included in review. The studies were published from1992 to 2017. Seven studies were reported from the UK [8-14], four studies from Turkey [3,4,15,16], two studies from Italy [17,18], five studies from India [1,5,19-21], one study from China [22], one study from Brazil [23], one study from Saudi Arabia [24],one study from Syria [25], one study from Canada [26], one study from Sweden [27], and one study from Malaysia [28]. The variables were compared in TB group with Anderson [8], Monoblock [2], Bass, TB + Headger [9], Herbst [3,4,10,17,22], Mini-block [11], Bionator [1,21], Dynamax [12-14], Activator [16,22], Extra oral maxillary splint (Thurow) [23], Mandibular protraction appliance(MPA-IV) [5,20], Forsus fatigue resistance device (FFRD)[18,19,24], Bite-Jumping [25], Xbow [26], Activator-headgear, Eruption guidance [27], and one study compared reverse TB compared with reverse Pull Face [28].The participants in each group have been shown in Table 1. Average treatment/observation time was from 5.81 to 16.20 months.

Table 1 Characteristics of the studies included in review

Reference, year	Country	Intervention: Participants	Average treatment /observation time (in months)
Trenouth, 1992 [8]	UK	Twin block: 10 Andresen: 10	-
Tümer, 1999 [15]	Turkey	Twin block:13 Monoblock:13	10 and 7 for monoblock and TB groups
McDonagh, 2001 [9]	UK	Twin block:12 Bass:17 Twin block + Headgear:13	10
O'Brien, 2003 [10]	UK	Twin block:85 Herbst:98	5.81 and 11.22 for Herbst and TB groups
Sharma, 2005 [11]	UK	Twin block:- Mini-block:-	12
Franchi,2006 [17]	Italy	Twin block:16 Herbst:35	-
Jena, 2006 [1]	India	Twin block:25 Bionator:20	-
Lee, 2007 [12]	UK	Twin block: 28 Dynamax: 28	0 – 9 and 9 – 12
Song, 2008 [22]	China	Twin block:20 Activator:20 Herbst:20	-
Varlik, 2008 [16]	Turkey	Twin block:25 Activator:25	9 and 8 for activator and TB groups
Fernandes, 2010 [23]	Brazil	Twin block:19 Thurow:19	12
Jena, 2010 [5]	India	Twin block:25 MPA-IV:15	Around 6
Thiruvenkatachari, 2010 [13]	UK	Twin block:32 Dynamax:32	9
Mahamad, 2012 [19]	India	Twin block:25 FFRD:25	12 and 15 for TB and FFRD groups
Baysal, 2013 [3]	Turkey	Twin block:20 Herbst:20	15.81 and 16.20 for Herbst and TB groups
Jena, 2013 [20]	India	Twin block:21 MPA-IV:16	Around 6
Lee, 2013 [14]	UK	Twin block:68 Dynamax:61	15–18
Baysal, 2014 [4]	Turkey	Twin block:20 Herbst:20	15.81 and 16.20 for Herbst and TB groups
Chavan, 2014 [21]	India	Twin block:10 Bionator:10	6
Hanoun, 2014 [24]	Saudi Arabia	Twin block:37 FFRD:30	Around 6
Burhan,2015 [25]	Syria	Twin block:20 Bite-Jumping:20	12
Ehsani, 2015 [26]	Canada	Twin block:25 Xbow:25	Variable

Giuntini, 2015 [18]	Italy	Twin block:28 FFRD:36	Around 6
Nilsson, 2016 [27]	Sweden	Twin block:38 Activator-headgear:38 Eruptionguidance: 47	-
Fareen, 2017 [28]	Malaysia	Reverse Twin block:49 Reverse Pull Face:46	-

Table 2 shows the important conclusions of each study included in the systematic review that five studies didn't have full-text [8,22,23,27,28].

Table 2 The important conclusions of the studies included in review

Study, year	Conclusion
Trenouth, 1992 [8]	The treatment time for TB group was significantly less than the Andresen group.
Tümer, 1999 [15]	The stimulation of mandibular growth and the correction of the Angle Class II relationship were achieved. Particularly in TB group, the SNA and Co-ANS values decreased, mandibular plane angle and gonial angle increased, and a decrease in the degree of over-bite occurred. Within both treatment groups, facial convexity and overjet decreased a distal movement of the upper molars and the mesialization of the lower molars was observed. In the monoblock group, upper incisors demonstrated a greater degree of retrusion and the interincisor angle increased. However, within TB group the lower incisors showed a greater degree of protrusion.
McDonagh , 2001 [9]	All three appliances produced an improvement in the soft tissue profile and there were no significant differences between them. The addition of headgear to the TB, without incisal coverage, did not control the vertical dimension.
O'Brien, 2003 [10]	Patient cooperation with the Herbst appliance is better than that with TB. Phase I treatment is more rapid with the Herbst appliance, but overall duration of treatment is similar to that with TB. The Herbst appliance is prone to debonding and component breakage. There are no differences in the dental and skeletal effects of treatment between the 2 appliances, but there was a marked sex effect: girls responded to treatment better than boys.
Sharma, 2005 [11]	The TB appliance produced a greater overall improvement in the soft tissue profile than the MB appliance. Initial treatment changes in both the vertical and horizontal dimensions partially relapses during the initial 3-month post treatment phase. A short 2- to 3-month interval should be left between functional and fixed appliance therapy to accurately assess anchorage requirements for ongoing fixed appliance therapy. The change in appearance is 3-dimensional and can be accurately measured. Movement of the soft tissue chin is closely related to the underlying bony structures. There is large variation in patients' responses to treatment with the TB and MB appliances.
Franchi,2006 [17]	Each new Class II patient at the peak in skeletal maturation (CS 3) with a pretreatment value for CoGo-Me_ smaller than 125.5_ is expected to respond favorably to treatment including FJO. Each new Class II patient at CS 3 with a pretreatment value for Co-Go-Me_ greater than 125.5_ is expected to respond poorly to treatment including FJO. Vertical and sagittal craniofacial features before treatment are not able to improve this prediction based upon mandibular morphology.
Jena, 2006 [1]	Neither appliance was efficient in restricting forward growth of the maxilla. Both appliances increased mandibular growth, but TB induced more mandibular growth than the bionator. Both appliances were significantly effective in restricting forward movement of the maxillary molars. Both appliances resulted in mesial movement of the mandibular molars, with TB producing slightly more movement than the bionator. Both appliances helped dramatically in molar correction, and

	TB corrected the molar relationship more efficiently than the bionator. Forward movement of the maxillary incisors was restricted by the appliances. The TB and bionator appliances caused significant forward movement of the mandibular incisors. Both appliances were effective for overjet reduction in Class II Division 1 malocclusion patients, but TB appliance was better than the bionator.
Lee, 2007 [12]	Forward movement of the chin and pogonion was similar cephalometrically with the TB at 2.1 mm and the Dynamax 2.0 mm. There was a slightly greater increase in the skeletal vertical dimension with the TB (3.2 mm) than the Dynamax (2.8 mm) which was statistically significant, $P = 0.03$, but of small magnitude. St TAFH increases were more with the TB, 3.6 mm, than the Dynamax 2.0 mm ($P = 0.036$). The soft tissue changes in lower lip length were similar to the face height changes, and forward movement of lower sulcus slightly more than that at the chin. The absence of a labial bow on the TB and the use of a torquing spring on the Dynamax reduced tipping of the upper incisors. Both appliances produced the greatest rate of change during the first 6 months of treatment and withdrawal of the appliances was associated with relapse, particularly with the TB. Considerable individual variation was found with all appliances, and further investigation into the ideal duration of treatment is required.
Song, 2008 [22]	Treatment effects of three different functional appliances (TB, Activator, and Herbst) are similar in the early treatment of skeletal Class II malocclusion. Compared with TB and Activator, Herbst has more effects on orthopedic of mandibular and lower anterior teeth.
Varlik, 2008 [16]	Growing Class II division 1 patients revealed significant profile changes after TB and activator treatment. The effects of activator and TB treatment on the soft tissue profile were similar; they both significantly changed the soft tissue profile. Among the evaluated measurements, their effects differed from each other only for the measurements Ss – y, Ss – E, and Si – E and nasolabial angle. The most pronounced effects of both appliances were forward movement of mandibular soft and hard tissue landmarks. Values defining the differences between T0 and T1 were subject to a large range of values, demonstrating a large variation in individual response. Longitudinal studies are required to evaluate the stability of the observed soft tissue changes.
Fernandes, 2010 [23]	These tests showed that TB promotes a significant increase ($P<.001$) in the total length of the mandible, as well as an increase in anterior facial height. In contrast, ANB and NAPog were reduced. In both treatment groups, the maxillary incisors retruded significantly ($P<.001$), although more so in TB group. In the Thurow appliance group, the mandibular incisors protruded significantly ($P<.001$). All other differences between the two treated groups were not significant.
Jena, 2010 [5]	Neither appliance was efficient in restricting the forward growth of the maxilla. TB appliance was more efficient in increasing the extra mandibular length; the extra mandibular growth by MPA-IV was comparable to that in untreated Class II subjects. MPA-IV caused distalization of maxillary molars; TB restricted the forward movement of the maxillary molars. Both appliances produced mesial movement of the mandibular molars. Both appliances caused palatal movements of the maxillary incisors; labial movement of the mandibular incisors was greater with MPA-IV. Both appliances were effective in molar correction and overjet reduction, but TB had more skeletal contribution than the MPA-IV.
Thiruvenkatachari, 2010 [13]	The TB appliance was more effective than the Dynamax appliance in overjet reduction. The patients who used the Dynamax appliance had more adverse events than did the TB patients. Orthodontic appliances should be tested in high quality studies (RCTs) before their introduction to the market. All trials should have a formal group of independent experienced people (DMC), and their role and terms of reference should be formulated before the trial.
Mahamad, 2012 [19]	Both TB and Forsus induced mandibular growth, but TB induced more mandibular growth than the Forsus. Both functional appliances showed no significant effect on restricting the forward growth of the maxilla. Significant decrease in overjet and overbite were observed at the end of treatment in TB and Forsus groups, when compared with untreated Class II subjects. The TB appliance produced both skeletal and dentoalveolar changes whereas Forsus FRD produced more dentoalveolar effects. Soft-tissue profiles improved significantly, reflecting the changes that took

	place in the Skeletal and dentoalveolar structures. These soft-tissue changes helped improve convex facial profiles.
Baysal, 2013 [3]	The effects of Herbst and TB treatment on the soft tissue profile were similar; they both significantly changed the soft tissue profile. Greater advancement of soft tissue pogonion and lower lip were observed in TB group.
Jena, 2013 [20]	There were improvements in the adaptations of the soft palate following treatment of Class II malocclusion by functional appliances. The growth of the nasopharynx occurred independent of functional appliance treatment. Both TB and MPA-IV were effective in improving the DOP among subjects with retrognathic mandibles, but the improvement was significantly greater with use of TB appliance. TB treatment was effective in the improvement of the hypopharyngeal airway passage dimension.
Lee, 2013 [14]	Clinically significant skeletal and soft-tissue changes were achieved with 15 month therapy with both TB and Dx appliances. The changes seen were greater with the TB in both antero-posterior movements and vertical movements, both cephalometrically and with laser scans. The antero-posterior movement of the chin with the Dx was not greater than would be expected with normal growth, with the main change seen in anterior total face height. The gradual forward mandibular movement with incremental advancement of the Dx was not associated with more favorable forward growth, or less movement of the incisors. Soft-tissue changes are identifiable with optical surface laser scans with a 3D mean increase in mandibular length of 8.1 mm TB, 6.8 mm Dx. The anterior face height increase with both appliances was equivalent at 6.1 mm. There is a small degree of relapse occurring with both appliances in some individuals in the 3 months after appliance withdrawal but less than previously reported when appliances were worn for shorter period of time.
Baysal, 2014 [4]	Therapies with both appliances resulted in correction of Class II relationship, reduction of overjet, and improvement in skeletal discrepancy. The only statistically significant differences between treatment groups were recorded for mandibular incisor position and skeletal discrepancy. After treatment, incisor protrusion was higher in the Herbst group and skeletal discrepancy improvement was greater in the TB group. TB appliance therapy resulted in greater skeletal changes than Herbst therapy. Correction of Class II malocclusion with Herbst therapy could be a combination of dental and skeletal changes.
Chavan, 2014 [21]	MRI demonstrated translation of the mandibular condyle by TB and Bionator appliances to the crest of the eminence at the beginning of the treatment, but after 6 months of treatment, the mandibular condyle had apparently moved back into the glenoid fossa. However, the condyles occupied a more anterior position in the fossa, to its pretreatment position.
Hanoun, 2014 [24]	The FRD and TB are effective in the treatment of patients with class II malocclusion. Both appliances were able to induce favorable changes in the sagittal relation, but the type of change differed significantly between the groups. The TB induced mandibular skeletal correction with much less influence on the maxilla. The FRD induced dentoalveolar changes, and the contribution to the final overjet correction was a result of an equal combination of upper incisor retroclination and lower incisor proclination.
Burhan,2015 [25]	Both the BJA and the TBA are recommended for the functional treatment of skeletal Class II malocclusion resulting from the retrusion of the mandible. The two appliances produce similar changes in the sagittal plane, including significant advancing of the mandible, no significant changes in the maxilla, lower incisor proclination, and upper incisor retrusion. Significant differences in the vertical plane were observed. The BJA motivated mandibular clockwise rotation, whereas the TBA induced fewer changes in the vertical plane. Likewise, some variables, the proportion of Jarabak, for example, indicated that the TB motivated some mandibular counterclockwise rotation.
Ehsani, 2015 [26]	Class II correction with an XBow or TB followed by orthodontic brackets and archwires is achieved by a combination of dentoalveolar and skeletal effects without vertical changes. Although treatment results for most variables with both approaches were found to be similar, differences

	were identified for Wits (1.6 mm), Go-Pog (4.3 mm), and L1-MP (3.3u). The TB group had a larger sagittal increase in mandibular length, while the XBow group experienced greater incisal proclination. No overall treatment time differences were detected.
Giuntini, 2015 [18]	Both treatment protocols (TB and FRD) were effective in correcting Class II malocclusion, with over an 80% success rate noted in consecutively treated patients in both groups. The TB produced greater skeletal effects than did the FRD in terms of mandibular advancement and growth stimulation. The Class II correction induced by the FDR was more dentoalveolar than was the TB, with a large amount of proclination of the mandibular incisors.
Nilsson, 2016 [27]	Mean overjet reduction per month was 0.6 mm for EGA which was lower than TBA group (0.7 mm) and A-HG groups (0.7 mm).The number of emergency visits and appliance breakage were lower in EGA group. However, there was no statistically significant difference between the 3 groups regarding ages, compliance, mean overjet reduction, emergency visits and appliance breakage aspects. In conclusion, this study indicates that EGA is an alternative choice in the treatment of adolescent patients with classIIdivision1malocclusion
Fareen, 2017 [28]	Both RTB and RPFM produced favorable craniofacial morphological changes in the treatment of Class III malocclusion. In comparison to RTB, advanced craniofacial changes were observed with RPFM. The skeletal improvements were more significant with RPFM. In comparison to the early mixed dentition stage, better craniofacial changes were observed in skeletal parameters during the late mixed dentition stage in patients treated with RPFM.

The comparison of mean differences, median differences, and mean differences of a number of cephalometric and skeletal variables between TB group versus the other groups in fourteen studies has been shown in Table 3 and Table 4.

Table 3 Comparison of mean differences (mean±SD), median differences (median [interquartile]) and mean differences (mean (95%CI)) between the twin block group versus the other groups in seven studies

Variable	Lee, 2007 [12]	Lee, 2013 [14]	Tumer, 1999 [15]	Varlik, 2008 [16]	Ehsani, 2015 [26]	Jena, 2013 [20]	Burhan, 2015 [25]
Overjet (mm)	-6[-4, -7.5] vs. -5[-4, -7]	-6.883±2.548 vs. -6.221±2.020	-7.46±2.45 vs. -6.39±1.37	NA	NA	NA	-4.75±1.47 vs. -4.36±1.50
S – N (mm)	0.6[0.2, 1.2] vs. 0.4[0.1, 0.9]	0.862±3.282 vs. 0.884±2.995	NA	NA	NA	NA	0.51±0.32 vs. 0.64±0.50
ANB (°)	**-2.0[-2.4, -1.0] vs. -1.1[-1.6, 0.1]***	**-2.501±2.248± vs. -0.986±2.496***	4.1±1.32 vs. 3.3±1.18	NA	NA	NA	-3.95±0.97 vs. -3.51±1.28
A – S vertical (mm)	0.1[-0.9, 1.0] vs. 0.4[-0.5, 0.8]	**1.305±4.977 vs. -0.638±4.009***	NA	NA	NA	NA	NA
Pog – S vertical (mm)	2.1[1.1, 4.7] vs. 2.0[0.5, 3.5]	**5. 203±9.635 vs. 0.726±7.234***	NA	NA	NA	NA	NA
Total anterior face height (mm)	**3.2[2.8, 4.4] vs. 2.8[1.2, 4.6]***	6.386±7.629 vs. 5.545±5.660	NA	NA	NA	NA	NA

Lower anterior face height (mm)	**2.35[0.82, 6.0] vs. 0.88[-0.9, 3.8]**	3.733±5.810 vs. 2.500±5.079	NA	NA	NA	NA	NA
U1-maxillary plane(°)	-3.2[-5.1, 0.9] vs. -1.7[-5.2, 0.6]	-5.1648.561 vs. -6.778±6.332	NA	NA	NA	NA	NA
L1 – mandibular plane(°)	2.3[-1.0, 4.4] vs. 2.3[-0.5, 6.2]	5.949±9.007 vs. 5.649±9.362	NA	NA	**6.3(4.2, 8.5) vs. 9.6(7.3, 12)***	NA	3.63±1.62 vs. 3.25±2.38
S vertical to Sulcus superius	1.22[0.63, 2.45] vs. 1.34[-0.54, 2.33]	**1.697±6.267 vs. -1.277±5.034***	NA	NA	NA	NA	NA
S vertical to Sulcus inferius	3.92[1.71, 6.01] vs. 2.09[-1.8, 3.49]	**6.370±7.232 vs. 1.003±5.972***	NA	NA	NA	NA	NA
S vertical to soft tissue Pog	3.71[1.4, 5.74] vs. 1.63[-1.19, 3.65]	**9.790±12.406 vs. 4.592±4.818***	NA	NA	NA	NA	NA
Labiomental angle (°)	10.71[3.54, 17.8] vs. 2.01[-6.54, 13.94]	14.365±19.145 vs. 12.785±16.051	NA	16.35±15.95 vs. 16.87±14.26	NA	NA	NA
SNB(°)	NA	NA	75.22.63 vs. 76.5±2.59	NA	NA	**3.28±1.15 vs. 1.44±0.73***	3.13±1.86 vs. 2.88±1.32
SNA (°)	NA	NA	79.3±2.61 vs. 79.8±2.59	NA	NA	**0.21±1.10 vs. -0.87±1.15***	-1.03±0.15 vs. -0.42±0.50
SN/Go-Gn	NA	NA	32.7±3.25 vs. 32.1±3.21	NA	NA	NA	NA
Overbite	NA	NA	2.3±1.21 vs. 2.0±1.21	NA	NA	NA	**0.58±1.39 vs. -1.25±1.32***
Nasolabial angle	NA	NA	NA	**6.23±3.10 vs. -0.80±2.83***	NA	NA	NA
IMPA	NA	NA	NA	1.86±0.95 vs. 2.71±1.38	NA	NA	NA
WITS	NA	NA	NA	NA	-4.9(-5.9, -4) vs. -3.4(-4.4, -2.4)	NA	NA

* P<0.05. **Abbreviations**: NA, not available.

Table 4 Comparison of median differences (median [interquartile]) and mean differences (mean (95 % CI)) between the twin block group versus the other groups in seven studies

Variable	Baysal, 2013 [3]	Baysal, 2014 [4]	Jena, 2010 [5]	Giuntini, 2015 [18]	Mahamad, 2012 [19]	O'Brien, 2003 [10]	Jena, 2006 [1]
Overjet (mm)	NA	8.42±2.35 vs. 8.68±2.84	6.79±1.71 vs. 5.87±1.00	**-8.0±2.9 vs. -5.1±2.1***	60.76±15.46 vs. 58.96±13.68	-6.27(-5.47, -7.00) vs. -5.80(-6.42, -5.18)	**6.31±1.71 vs. 4.95±2.00***
ANB (°)	-2.85±1.26 vs. -2.37±1.51	6.02±1.17 vs. 6.77±1.56	NA	**-2.6±1.3 vs. -1.8±1.3***	33.17±44.69 vs. 27.55±43.69	NA	NA
Total anterior face height	NA	119.90±6.54 vs. 121.85±6.95	NA	NA	NA	NA	NA
Lower anterior face height	NA	66.35±5.62 vs. 68.12±5.54	NA	NA	NA	NA	NA
L1 – mandibular plane	NA	39.90±3.55 vs. 41.32±2.92	NA	NA	NA	NA	NA
SNB(°)	**2.07±1.36 vs. 0.92±1.18***	74.70±1.77 vs. 74.10±2.08	NA	**2.4±1.2 vs. 0.5±1.5***	**6.76±1.69 vs. 0.71±5.96***	NA	NA
SNA (°)	-0.75±1.03 vs. -1.35±1.11	80.72±0.99 vs. 80.92±1.13	NA	**-0.2±1.3 vs. -1.3±1.6***	**0.60±2.73 vs. 0.52±1.95***	NA	NA
SN/Go-Gn (mm)	-0.25±2.57 vs. 0.10±1.67	31.20±4.54 vs. 34.30±3.66	NA	**9.4±3.1 vs. 7.4±3.5***	NA	NA	NA
Overbite (mm)	NA	4.42±1.87 vs. 4.25±1.57	NA	-3.3±3.0 vs. -3.1±2.0	NA	NA	NA
L1-NB	2.70±4.39 vs. 5.20±3.45	NA	NA	NA	**18.65±18.88 vs. 34.48±26.37***	NA	NA
Nasolabial angle	-0.35±12.39 vs. -0.45±7.75	NA	NA	NA	**5.81±11.96 vs. 1.44±4.67***	NA	NA
H-angle	-4.6±4.48 vs. -2.75±2.96	NA	NA	NA	13.47±13.70 vs. 12.29±9.67	NA	NA
IMPA	**0.92±3.77 vs.**	NA	NA	NA	**2.22±4.74**	NA	NA

	4.20±3.20*				**vs. 5.73±4.16***		
WITS	NA	NA	NA	NA	55.18±42.73 vs. 44.07±43.59	NA	NA
Total U6	NA	NA	**0.07±1.21 vs. 1.72±0.49***	NA	NA	NA	0.07±1.21 vs. -0.31±1.36
Total L6	NA	NA	1.46±1.26 vs. 1.89±0.36	NA	NA	NA	1.45±1.26 vs. 1.35±0.82
Total U1	NA	NA	1.45±1.33 vs. 1.72±0.49	NA	NA	NA	1.45±1.33 vs. 0.59±1.67
Total L1	NA	NA	**1.27±0.96 vs. 1.89±0.36***	NA	NA	NA	1.27±0.96 vs. 0.50±0.76
ABCH	NA	NA	**4.07±1.53 vs. 3.05±4.32***	NA	NA	NA	3.69±1.53 vs. 2.86±1.18
Molar correction	NA	NA	5.60±1.78 vs. 5.87±1.00	NA	NA	NA	**5.11±1.78 vs. 3.90±1.45***

* P<0.05. **Abbreviations**: NA, not available.

Table 4 continues…

Variable	Baysal, 2013 [3]	Baysal, 2014 [4]	Jena, 2010 [5]	Giuntini, 2015 [18]	Mahamad, 2012 [19]	O'Brien, 2003 [10]	Jena, 2006 [1]
Molar relation	NA	-5.5±1.89 vs. -4.58±1.90	NA	-2.4±1.6 vs. -1.7±1.5	NA	-3.62(5.7, 6.69) vs. -3.03(-3.53, -2.53)	NA
Maxillary molar	NA	-0.52±1.57 vs. -1.00±1.29	NA	NA	NA	0.4(-0.21, 1.02) vs. 0.48(-0.19, 1.14)	NA
Mandibular molar	NA	0.35±1.79 vs. 1.22±2.23	NA	NA	NA	1.45(0.66, 2.55) vs. 1.07(0.61, 1.53)	NA
Maxillary incisor	NA	-0.45±1.81 vs. -0.95±1.82	NA	NA	NA	-3.11(-2.31, -3.91) vs. -2.43(-3.00, -	NA

						1.85)	
Mandibular incisor	NA	**-0.15±3.00 vs. 1.77±2.29***	NA	NA	NA	0.56(-0.29, 1.13) vs. 0.94(0.37, 1.51)	NA
Maxillary base	NA	0.45±1.22 vs. 0.70±1.34	NA	NA	NA	1.85(1.2, 2.49) vs. 1.22(0.70, 1.74)	NA
Mandibular base	NA	4.62±3.09 vs. 3.05±2.25	NA	NA	NA	4.42(3.63, 5.20) vs. 3.66(2.89, 4.43)	NA
Condylar head	NA	0.68±1.64 vs. 0.4±1.07	NA	NA	NA	-0.96(-0.51, -1.39) vs. -0.30(-0.67, 0.08)	NA

* P<0.05. **Abbreviations**: NA, not available.

TB versus Anderson

In study of Trenouth et al. [8], ten patients with class II division 1 malocclusion was treated with TB appliance and ten with Anderson appliance. The comparing the patient groups before and after treatment, the significant difference was in upper incisor angulation and angle ANB in Andresen and TB groups. Both functional appliances produced some bodily correction with an improvement in the dental base relationship. Although the TB appliance group showed a greater reduction in angle ANB, this was not significantly different from that in the Andresen appliance group. The treatment time for the TB group was significantly less than the Andresen group. Totally, TB can be better treatment than Andersen.

TB versus Monoblock

One study [15] compared the efficacy of TB in 13 patients compared with Monoblock in 13 patients of class II division 1 malocclusion. The findings of this study revealed that by using these different functional appliances, the stimulation of the growth of the lower jaw and the correction of Angle Class II relationship were achieved. The mandibular plane angle (SN/GoGn) increased significantly only in TB group during the study period, although a significant decrease in the degree of overbite occurred. In the monoblock group, upper incisors demonstrated a greater degree of retrusion. However, within TB group, the lower incisors showed a greater degree of proclination. A significant decrease in the degree of overjet was seen in both of the treatment groups. Totally, TB can be better treatment than Monoblock.

TB versus Bass and TB + Headgear

Twelve patients in TB, 17 in Bass, and 13 in TB plus Headgear group were compared in one study by McDonagh and their colleagues [9]. There were no significant differences between there groups for cephalometric values and improvement in the soft tissue profile was similar. Totally, treatment with TB was similar to Bass and TB plus Headgear.

TB versus Herbst

One-hundred and sixty-one patients were included in TB group and 173 in Herbst group [3,4,10,17,22]. O'Brien et al. [10] reported there were no differences in treatment time between two appliances, but significantly more appointments were needed for repair of the Herbst appliance than for TB, but because of the high cooperation rates of patients using it, the Herbst appliance could be the appliance of choice for treating adolescents with class II division 1 malocclusion. Franchi et al. [17] predicted mandibular changes functional jaw orthopedics followed by fixed appliances in TB group compared with stainless steel crown Herbst and acrylic splint

Herbst groups. Pretreatment vertical and sagittal parameters were not able to improve the prediction based upon the mandibular angle. Song et al. [22] concluded that treatment effects of two different functional appliances (TB and Herbst) were similar in the early treatment of skeletal Class II malocclusion. Compared with TB, Herbst has more effects on orthopedic of mandibular and lower anterior teeth. Two studies by Baysal [3,21] showed that both appliances reduced the soft tissue profile convexity when the nose is not taken into consideration and greater advancement of mandibular soft tissues was observed in TB group and also Herbst appliance may be especially useful in skeletal class II patients with maxillary dentoalveolar protrusion and mandibular dentoalveolar retrusion. Studies showed SNB, IMPA [3], and mandibular incisor [4] were significantly different between two appliances.

TB versus Mini-block

Sharma et al. [11] showed that changes in the soft tissue was similar in TB appliance compared with MB appliance ($P>0.05$).

TB versus Bionator

Thirty-five patients were treated with TB appliance and 30 patients with Bionator appliance [1,21].Jena et al. [1] concluded TB was more efficient than bionator in the treatment of class II division 1 malocclusion and also Chavan et al. [21] showed that temporomandibular joint changes was similar in two groups.

TB versus Dynamax

Three studies included 128 patients treated with TB and 121 patients with Dynamax appliance [12,13,14]. The soft tissue vertical cephalometric in TB significantly increases more than Dynamax. Also, increasing of antero-posterior skeletal change total anterior face height in TB was more than Dynamax [12]. TB appliance was more effective than Dynamax appliance when overjet was evaluated and Dynamax appliance patients reported greater incidence of adverse events with their appliance than those who were treated with TB appliance [13]. The results demonstrated both appliances corrected the overjet with significantly increased skeletal dimensional changes, mandibular length, total anterior face height with TB compared with Dynamax. The cephalometric soft-tissue changes and lower labial sulcus region where forward movements were significantly different between the two appliances at soft-tissue pog onion were observed [14]. Studies showed ANB [12,13], A – S vertical, Pog – S vertical [13],total anterior face, lower anterior face [12], S vertical to Sulcus superius, S vertical to Sulcus inferius, and S vertical to soft tissue Pog [13] were significantly different in two groups.

TB versus Activator

Two studies [16,22] included 45 patients in each group (TB and Activator groups). Treatment effects of two different functional appliances were similar in the early treatment of skeletal class II malocclusion [22]. The effects of two appliances on the soft tissue profile were similar; both significantly changed the soft tissue profile [16].

TB versus Thurow

Fernandes et al. [23] concluded that effectiveness of two appliances for the correction of class II relationships was similar, except a significant increase in the total length of the mandible and anterior facial height occur in TB group, the maxillary incisors retruded significantly in two groups and the mandibular incisors protruded significantly in Thurow group.

TB versus MPA-IV

Two studies [5,20] included 46 patients in TB group and 31 patients in MPA group. Total U6, Total L1, ABCH [5], SNB, and SNA [20] were significantly different in two groups. TB appliance contributed more skeletal effects [5] and more effective in the improvement of PAP dimensions with retrognathic mandible than MPA-IV appliance for the correction of class II malocclusion [20].

TB versus FFRD

Three studies [18,19,24] included 115 patients treated with TB appliance and 116 patients with FFRD appliance. Class II correction with TB is more due to skeletal changes [19,21], whereas in Forsus, it is more due to dentoalveolar changes [19]. TB appliance produced greater skeletal effects in terms of mandibular advancement and growth stimulation while Forsus caused significant proclination of the mandibular incisors. [24] Overjet, ANB, [18] SNB, SNA [19,18],SN/Go-Gn[18],L1-NB, Nasolabial angle, and IMPA [14] were different between two appliances.

TB versus Bite-Jumping

Burhan et al. [25] reported two appliances were effective in functional treatment of skeletal class II malocclusion resulting from the retrusion of the mandible. BJA was effective when clockwise rotation was desired, whereas the TBA was recommended to inhibit vertical development.

TB versus Xbow

Ehsani et al. [26] concluded that XBow or TB appliances followed by fixed appliances had similar effects on class II correction. An increase in mandibular incisor inclination for the XBow group and an increased corpus length for TB group were notable exceptions.

TB versus Activator-headgear and Eruption guidance

Nilsson et al. [27] indicated that Eruption guidance is an alternative choice in the treatment of adolescent patients with class II division 1 malocclusion.

Reverse TB versus Reverse Pull Face

Fareen et al. [28] showed that Reverse Pull Face revealed more favorable craniofacial changes than Reverse TB, particularly in the late mixed dentition stage.

Limitations

Two important limitations were: 1) The studies included in systematic review were not homogenous in terms of measured variables. 2) The treatment time was different in studies.

2. CONCLUSION

Class II correction in TB appliance therapy was more due to skeletal changes compared with most other appliances. The most ability of TB appliance was on mandibular changes. Also, TB could be suitable treatment in patients with class II malocclusion and therefore using TB appliance in early orthodontic treatment is recommended in these patients.

CONFLICT OF INTEREST

The authors have declared that there was no conflict of interest.

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