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ORIGINAL ARTICLE

MANDIBULAR ARCH CHANGES FOLLOWING EXPANSION WITH SCHWARZ APPLIANCE IN GROWING PATIENTS – A SYSTEMATIC REVIEW.

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ABSTRACT

Aim and Objectives

The aim of this review is to systematically evaluate and assess the available evidence on arch dimensional changes in the mandible following expansion using Schwarz Appliance in growing patients.

Materials and Methods

The protocol for the review was registered with the PROSPERO database. A systematic search was done on the following scientific databases PubMed, Cochrane Central, LILACS and Google Scholar to identify articles of relevance published until April 2021. Articles that satisfied the inclusion criteria were included in the review. The review was performed based on the PRISMA guidelines. MINORS tool was used to evaluate the Risk of Bias and quality of evidence of the included studies.

Results

243 trials were identified after implementing the search strategy. After eliminating duplicates 196 trials remained. After screening the titles and abstracts for the eligibility criteria, 190 trials were eliminated from further review. Full text was sought for the remaining six articles and one study was eliminated after review of the full text. Four the included studies showed low Risk of Bias in their methodologies and one study showed a low risk of Bias in its methodology. Qualitative analysis was performed on the remaining five trials. The studies significant increase in the Intermolar, intercanine, interpremolar and arch perimeter and also observed significant up righting of the permanent mandibular first molar.

Conclusion

Arch dimensional changes in the mandible of growing patients after expansion using Schwarz Appliance are dento-alveolar in nature. No skeletal Expansion is seen.

Key Words: Expansion, Schwarz Appliance, Growing Patients.

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INTRODUCTION

In recent years, the non-extraction approach to address malocclusion has been gaining prominence. Many patients can now be treated without having their permanent teeth extracted thanks to a plethora of advancements. The maxillary arch has been effectively lengthened using a variety of appliances, including headgears, palatal expanders, and molar distalization appliances [1-3]. However, acquiring space in the mandibular arch has been a limiting problem. Addressing the constriction in the mandible is more challenging than in the maxilla owing to the absence of a suture that can be opened up and the structural and anatomic resistance offered by the mandibular body [4,5].

Several authors highlight that a moderate increase in the mandibular arch width is possible, especially in the anterior regions of the arch, until the eruption of the permanent canines [6-17]. After this, arch width usually tends to decrease in both the anterior and posterior regions. Crowding in the mandibular arch is a very common occurrence in patients with various malocclusions and its extent is a determining factor in non-extraction treatment. Consideration should be given to resolve crowding of teeth by arch expansion without upsetting the stability [18-24].

The term Schwarz appliance has been credited to A.M. Schwarz but it was Kingsley who first introduced the use of jack-screw in a lower removable plate made of vulcanite. This appliance was split bilaterally near the mandibular canines [14]. The modern iteration of Schwarz appliance is a horseshoe-shaped removable acrylic appliance with a midline expansion screw that fits along the lingual border of the mandibular dentition [14,25]. The appliance is used for transverse arch expansion in the mandible and is commonly used along with Rapid Maxillary Expansion in the maxilla. Standalone uses of the Schwarz appliance are rare except for posterior teeth buccal crossbites. The appliance is usually activated once per-week until 4-5mm of anterior expansion is achieved. Various authors have examined the effect and success of transverse expansion in the mandible [14,25-31]. This review aims to systematically analyse the available literature evidence on the effects of using the Schwarz appliance for arch expansion on the mandibular arch in growing subjects.

MATERIALS AND METHODS

Protocol Registration

Protocol for this review was registered with the PROSPERO database (www.crd.york.ac.uk/prospero, protocol number - CRD42021245070). The Preferred Reporting Items for Systematic Reviews and Meta-Analyses guidelines were followed while preparing this review.

Eligibility Criteria

A PICOS question (Table 1) was formulated to help in the selection process for the various studies that would be considered in this review. A comprehensive and systematic literature search strategy based on the PICOS was adopted. Considering the various syntax limitations of various

databases, a separate search strategy was developed for the following databases PubMed, Cochrane CENTRAL, LILACS, and Google scholar (Table 2) to identify the articles of relevance. The search strategy was limited to randomized control trials and non-randomised controlled clinical trials. Only articles published in the English language or that had an English language translation attached were considered for this review. A further search in the following journals - American Journal of Orthodontics and Dentofacial Orthopaedics, European Journal of Orthodontics, Journal of Orthodontics, and Angle Orthodontist was also done to identify articles of relevance.

Table 1 - PICOS Table

POPULATION	Patients in the early mixed dentition phase having mandibular anterior dental crowding.
INTERVENTION	Arch expansion performed using Schwarz appliance to correct mandibular anterior dental crowding.
CONTROL	Non-treated cases, where no expansion was performed in the mandible for anterior dental crowding.
OUTCOME	Changes in the mandibular arch dimension as assessed by parameters such as intermolar width, arch perimeter, first molar inclination, intercanine width and interpremolar width.
STUDY DESIGN	Randomized control trials and non-randomized Clinical trials were considered in this review for evaluation.

Table 2 - Search strategy used in the various databases

Database	Search Term used	Results
PubMed	(((((("mandibular expansion"[Title/Abstract] OR "Schwarz appliance"[Title/Abstract] OR ("Removable"[All Fields] AND "acrylic expander"[Title/Abstract])) OR "mandibular Schwarz appliance"[Title/Abstract]) OR "removable expansion appliance"[Title/Abstract]) OR (((("mandible"[MeSH Terms] OR "mandible"[All Fields]) OR "Mandibular"[All Fields]) OR "mandibulars"[All Fields]) AND "expander"[Title/Abstract])) OR ("Removable"[All Fields] AND	19

	(((((("acryl"[All Fields] OR "acrylated"[All Fields]) OR "acrylates"[MeSH Terms]) OR "acrylates"[All Fields]) OR "acrylation"[All Fields]) OR "acrylic acid"[Supplementary Concept]) OR "acrylic acid"[All Fields]) OR "acrylate"[All Fields]) OR "acrylic"[All Fields]) OR "acrylics"[All Fields])) AND "expansion screw"[Title/Abstract]) Filters: Clinical Trial, Randomized Controlled Trial	
LILACS	Schwarz appliance AND Mandibular arch Expansion AND Orthodontics	7
Google Scholar	Mandibular expansion "Schwarz Appliance"	197
Cochrane CENTRAL	Schwarz appliance	7
Other Sources	Mandibular Arch Expansion (Title) AND Schwarz appliance (Full Text)	13

Selection of Studies

Two reviewers (MT, RN) independently performed the study selection process. Each record retrieved was assessed independently. Titles that failed to meet the eligibility criteria (Table 3) were excluded from the review process. The remaining articles were further scrutinized and the full text of these articles was reviewed. The reference list of the included studies was hand-searched to identify other relevant studies. The two investigators combined their articles and extracted data. Conflicts among the reviewers were resolved in consultation with an independent reviewer (RKJ).

Table 3 - Inclusion and Exclusion Criteria

Inclusion Criteria	<ul style="list-style-type: none"> Controlled Clinical Trials (Randomised and Non-randomised). Arch expansion parameters evaluated using models or radiographs. Control group and study group participants of similar age group and growth status. Intervention group participants to be in the mixed dentition phase during the intervention.
Exclusion criteria	<ul style="list-style-type: none"> Unpublished trials. Pilot trials. FEM and animal studies.

Data Items and Collection

The following information was determined for all articles included in qualitative analysis: - names of the authors, year of publication, study design, sample size, number and participant groups, type of intervention, comparative groups, and parameters of evaluation. (Table 5)

Risk of Bias assessment in individual studies

The Methodological Index for Non-randomised trials (MINORS) tool ^[32] was used to evaluate the risk of bias for the non-randomised studies included in this review (Table 4).

Table 4 - MINORS tool for assessment of Risk of Bias of Non-Randomised studies included in the review.

Quality Item	Grady et al	Motoyoshi et al	Tai and Park	Tai et al	Tai et al
A clearly stated aim	2	2	2	2	2
Inclusion of consecutive patients	2	2	2	2	2
Prospective collection of data	2	2	2	2	2
Endpoints appropriate to the aim of the study	2	2	2	2	2
Unbiased assessment of the study end point	2	2	2	2	2
Follow-up period appropriate	2	1	1	1	1
Loss to follow-up less than 5%	2	2	2	2	2
Prospective calculation of the study size	0	0	0	0	0
An adequate control group	1	1	2	2	2
Contemporary groups	2	2	2	2	2
Baseline equivalence of groups	2	2	2	2	2
Adequate statistical analyses	2	2	2	2	2
Total	21	20	21	21	21

RESULTS

Determination of relevance

After a thorough search the scientific databases using the search terms, a total of 243 articles were identified. After removing the duplicates 196 articles that obtained which were then subjected to title and abstract screening for eligibility into the study based on the inclusion criteria. 190 of these studies were eliminated after screening of the titles and abstracts. Full-texts of the remaining six articles were sourced. After evaluating the full text, one study^[33] was excluded as only cephalometric changes of arch expansion were only evaluated. Five studies that remained after full-text evaluation were then included for the qualitative analysis^[34–38] in the review. A quantitative analysis could not be performed due to the methodological difference inherent in the studies included for review. The process for selection studies is described in the PRISMA study flow diagram chart (Figure 1). During the evaluation of the full-text of the studies, three studies with similar methodologies and results tables were identified^[35,36,38]. Two of these also had the same no. of participants^[35,36]. These three studies also shared the same investigators, corresponding author and same institutional setup. Thus, the corresponding author was contacted for further clarification. The response obtained was that the studies had an overlap of participants and in the study by Tai et al (2011)^[38] the sample size was increased and the additional participants were evaluated. The corresponding author in the response also emphasised on the fact that the investigator performing outcome evaluation was blinded in all the studies. The primary and secondary reviewers in consultation with the independent third reviewer thus arrived at the decision to include these studies for the qualitative analysis and consider their results individually.

Characteristics of the included studies

The total number of participants included in the review is 222, of which 85 participants were in the control group and 27 participants were in the RME-only group. Of the intervention participants relevant to this review, 23 were treated with Schwarz appliance combined with RME, 87 were treated with Schwarz appliance in both the arches. The included studies had similar activation protocols but differed in their wear protocols. Three of the included studies^[35,36,38] had their participants wear the appliance during the night and the other two included studies^[34,37] had the patients wear the appliance full time. The activation period varied from 6 months to 12 months and the retention period varied from 4 to 9 months in the included studies. Two of the included studies^[34,37] only used dental models for evaluation of the outcomes, whereas another two studies^[35,36] used CBCTs and dental models to evaluate outcome and the remaining one study^[38] only used CBCTs to evaluate the outcome.

Risk of bias and quality assessment in the studies

Four of the studies^[34–36,38] included in the qualitative analysis showed a low Risk of Bias. One study by Motoyoshi et al^[37] shows a high Risk of Bias. All of the included studies reported most of the protocol adequately. The study by Motoyoshi et al

^[37] was assessed to have a high Risk of Bias as it was a short-term study, had a smaller control group when compared to the intervention group and the investigators had not performed a prospective calculation of the sample size. The investigators of the other four included studies^[34–36,38] had also failed not perform a prospective calculation of the sample size. The studies by Tai and Park^[36], Tai et al (2011)^[38] and Tai et al (2010)^[35] were also short term studies but had 1:1 ratio of control group to participants. The study by O’Grady et al^[34] was a long-term study but had a smaller control group.

Results of individual studies and additional analyses

Intermolar width

All of the studies^[34–38] included in the qualitative analysis identified an increase in the intermolar width in patients treated with Schwarz appliance and this increase was significant when compared to the changes in untreated controls.

Arch Perimeter

Tai and Park^[36], O’Grady et al^[34] and Tai et al (2010)^[35] observed a statistically significant increase in the arch perimeter in the intervention group post-expansion when compared to the growth changes in the control group.

Molar inclination

The change in inclination of the permanent mandibular first molar was assessed in four of the included studies^[34,36–38]. Tai and Park^[36] and Tai et al (2011)^[38] used CBCTs to evaluate the change in the inclination of the permanent mandibular first molar and observed an up righting of the mandibular first molar in the intervention group post expansion which was significant when compared to the growth changes in the control group. O’Grady et al^[34] and Motoyoshi et al^[37] used observed an up righting of the mandibular permanent first molar in the intervention group post expansion and O’Grady et al^[34] and Motoyoshi et al^[37] found this difference to significant when compared to the growth changes of the control group.

Inter canine width

O’Grady et al^[34] observed a significant increase in the inter canine width in the intervention group when compared to the growth changes of the control group.

Interpremolar width

O’Grady et al^[34] and Tai et al (2010)^[35] identified an increase in the interpremolar widths post expansion and this difference was significant when compared to the growth changes of the control group.

Skeletal changes

Skeletal changes were evaluated using CBCTs in three included studies by Tai and Park^[36], Tai et al (2011)^[38] and Tai et al (2010)^[35]. Transverse Expansion of the mandibular body at the molar and premolar region was evaluated in these

3 studies and it was reported that no significant changes took place in patients treated with Schwarz appliance. The studies also observed an increase in the buccal and lingual inter dentoalveolar width at the molar region in patients treated with the Schwarz appliance.

DISCUSSION

Purpose of the review

While transverse expansion is anatomically possible to attain in the maxilla by opening the median palatine suture, application of this in the mandible is controversial as the suture fuses immediately after birth and not much evidence exists in the literature regarding mandibular expansion. Mandibular expansion has not received the same level of attention from researchers and academia. Various authors have explored the changes in the arch dimensions after expansion with Schwarz appliance. When removable appliances are utilised for expansion, the question of stability is a major concern to orthodontists. To address the arch-length tooth size discrepancy, it is necessary to gain space to overcome the shortage of space in the arch. A growing number of patients are requesting not to have extractions or have their teeth ground as much as possible to gain space. Accordingly, expansion has to be considered as an option to gain space.

Summary of evidence -

All included studies in the qualitative analysis observed an increase in the intermolar dental width. The studies by Tai et al (2010)^[35], Tai et al^[38] (2011) and Tai and Park^[36] had an overlap of participants and in this review their results are considered individually. These studies measured the changes post-expansion using CBCT and observed that there was only dentoalveolar expansion when Schwarz appliance was used for arch expansion. O'Grady et al^[34] and Tai et al^[35] further observed a similar increase in dental and dentoalveolar widths at the canine and premolar regions but no skeletal changes were appreciated in these regions. The significant change in inclination of the lower first permanent molar identified by O'Grady et al^[34] and Motoyoshi et al^[37] could be suggestive of the fact that the increase in intermolar width could be primarily due to the up righting of the first molar. Tai et al(2010)^[35], Tai and Park^[36] and Grady et al^[34] also observed that the expansion with Schwarz appliance had resulted in an increase in the arch perimeter. The overall Risk of Bias of the included studies was moderate. The different evidence of methodology limited the scope of this review to a qualitative analysis only.

Wendling et al^[33] in their study identified that patients treated with RME combined with Schwarz appliance therapy experienced an increase in LAFH 1.5mm which was significantly more than that seen in the RME only group. They also observed an increase in the lower posterior dental height and mandibular plane angle in patients treated by RME-Sz protocol when compared to patients treated by RME only. A 3D FEM study conducted by Shen et al^[39] also observed that the alveolar bone expanded when Schwarz appliance was used for expansion in the mandible but it did not produce any skeletal changes in the mandibular body when comparing against three fixed expanders.

The evidence to support stability in mandibular arch expansion is very low among the included articles as all of the studies except that by O'Grady et al^[34] are short term trials. O'Grady et al^[34] observes that the intermolar width mostly remains the same with a very minor non-significant decrease post fixed appliance therapy and the retention period after the fixed appliance therapy. The same observation is applicable to the other outcomes used to assess mandibular arch dimensional changes in this review. Little et al^[21,40,41] reports that the stability of the mandibular expansion is low. Shellhart et al^[42] from their experimental study reports that the primary culprit could possibly be the lips and soft tissues. However, he also observed that the soft tissues gradually adapt. This view is also supported by Boccaccio et al^[43] suggesting the masticatory muscular forces gradually weaken and become less significant overtime leading to greater stability. The activation protocol among the studies is similar but the pattern of wear is different as three studies utilized only night time wear whereas the other two trials used full-time wear protocol.

All this evidence is suggestive that the Schwarz appliance has more of a dentoalveolar effect than that of a skeletal effect when used to achieve expansion in the mandible during the early mixed dentition phase. Schwarz appliance is also seen to increase the range of expansion of the maxilla when used in conjunction with Rapid Maxillary Expansion. Schwarz appliance also can be utilized as an alternative to extraction in mild to moderate lower anterior dental crowding. McNamara also highlights the use of Schwarz appliance in dento-alveolar decompensation during the early mixed dentition/pre-adolescent phase. In a situation that demands the need for skeletal expansion such as in cases of severe transverse discrepancy Schwarz appliance will not be the right choice. The stability of the expansion is fully understood and more investigations into the matter are required to fully grasp and understand the question of stability.

Limitations

A major limitation of this review is the lack of RCTs, lack of popularity of the procedure both in clinical and research areas which has limited the number of trials that have explored the effects using Schwarz appliance for expansion in the mandible in growing children. Another limitation of this review is that a quantitative analysis could not be performed as all the included studies differed in their methodologies and three of the studies had an overlap of participants. Four of the trials included in the final review are short term in nature thereby not giving a broader perspective to the long-term effects of the use of Schwarz appliance for expansion in the mandible in growing patients. The language restriction applied in this review is also a determinant to the inclusion of more trials for qualitative analysis.

CONCLUSIONS

With the limited evidence available in this review, it can be concluded that,

- The Schwarz appliance when used for expansion in the mandible in growing patients has a dento-alveolar effect.
- The arch dimensional changes are primarily due to the buccal tipping of the dentition with only a partly by bodily movement.

CONFLICT OF INTEREST

The authors of this review have no conflict of interest to declare.

FUNDING

The authors of this review have no funding sources to declare.

Table 5 - Characteristics of the included studies

S.NO	AUTHOR/ STUDY DESIGN	GROUPS	GENERAL INFORMATION OF THE SUBJECTS	TREATMENT PROTOCOL	RECORDS TAKEN AT	OUTCOME EVALUATED
1	O'Grady et al 2006; PCT	Group 1 - (RME only) - Sample size - 27 Group 2- (RME-Sz) - Sample size - 23 Control group* - (No treatment) - Sample size - 16	Group 1 - RME only (11 male and 16 female) Group 2 - RME-Sz (9 male and 14 female) Controls (9 male and 7 female)	Group 1 - 5 months of RME (7-8mm) followed by retention with a palatal plate for 1 year. This is followed by FA after the eruption of all permanent teeth. Group 2 - 5 months of expansion with Schwarz appliance in the mandible (one quarter turn per week; 0.2mm) and RME (8-10mm; protocol similar to Group 1). This is followed by FA after the eruption of all permanent teeth.	T0 - Pre-treatment (Before expansion). T1 - Post expansion after retention before FA T2 - Post FA therapy. T3 - Three years after completion of FA.	Changes were assessed on digital scans of dental casts.
2	Tai and Park 2010; RCT;	Study Group - Sample size - 14 Control Group* - (No treatment) Sample size - 14	7 years and 11 months at T0; 9 years and 8 months at T1. Study group (6 male and 8 female) Control group (6 males and 8 females).	Use of Schwarz appliance in both arches in the intervention group. Patients wore appliances at night only. 6 to 12 months of expansion in the mandible; 9 months of retention.	T0 - Pre-treatment (Before Expansion). T1 - Post treatment after retention.	Measurements were taken on the axial CBCT section and dental casts to assess the changes

3	Tai et al 2010; RCT;	<p>Study Group - Sample size - 14</p> <p>Control Group* - No treatment Sample size - 14</p>	<p>7 years and 11 months at T0; 9 years and 8 months at T1.</p> <p>Study group (6 male and 8 female)</p> <p>Control group (6 males and 8 females)</p>	<p>Use of Schwarz appliance in both the arches for expansion in the intervention group. The appliance is activated once a week (0.175mm). 6 to 12 months of expansion in the mandible; 9 months of retention.</p>	<p>T0 - Pre-treatment (Before Expansion).</p> <p>T1 - Post treatment after retention.</p>	<p>Measurements were taken on the axial CBCT section and dental casts to assess the changes</p>
4	Tai et al 2011; RCT	<p>Study Group - Sample size - 30</p> <p>Control Group* - No treatment Sample size - 30</p>	<p>7 years and 11 months at T0; 9 years and 8 months at T1.</p> <p>Study group (15 male and 15 female)</p> <p>Control group (15 male and 15 female)</p>	<p>Use of Schwarz appliance in both arches in the intervention group. The appliance is activated once a week (0.175mm). Patients wore appliances at night only. 6 to 12 months of expansion in the mandible; 9 months of retention.</p>	<p>T0 - Pre-treatment (Before Expansion).</p> <p>T1 - Post treatment after retention.</p>	<p>Measurements were taken on the axial CBCT section to assess the changes.</p>
5	Motoyoshi et al 2005; PCT	<p>Study Group - Schwarz appliance Sample size - 29 (Average arch-length discrepancy of 5.24 ± 1.40 mm)</p> <p>Control Group* - No treatment Sample size - 11</p>	<p>Study group (10 males and 19 females; 6years 10months to 11 years 7months)</p> <p>Control group (4 males and 7 girls)</p>	<p>Use of Schwarz appliance in both arches in the intervention group. Post-expansion the expanders were used as retainers for 4-6 months. Followed FA after eruption of all permanent teeth.</p>	<p>T0 - Pre-treatment (Before expansion).</p> <p>T1 - Post expansion after retention before FA</p> <p>T2 - Post FA therapy.</p>	<p>Changes n were assessed using dental casts.</p>

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