Comparison of skeletal anchorage distalizers effect in maxillary buccal segment

A systematic review

Kaunas, 2018
Comparison of skeletal anchorage distalizers effect in maxillary buccal segment
A systematic review

Student.................... Work supervisor ........................................
(signature) (signature)

Lior Levin, 5th course, group 14 PhD, Arunas Vasiliauskas

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Kaunas 2018
# EVALUATION TABLE OF THE MASTER'S THESIS OF THE TYPE OF SYSTEMIC REVIEW OF SCIENTIFIC LITERATURE

**Evaluation:** .................................................................................................................................

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(Scientific degree. name and surname)

**Reviewing date:** .................................................................

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<th>No.</th>
<th>MT parts</th>
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<td>Summary (0.5 point)</td>
<td>Is summary informative and in compliance with the thesis content and requirements?</td>
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<td>3</td>
<td>Introduction, aim and tasks (1 point)</td>
<td>Are the novelty, relevance and significance of the work justified in the introduction of the thesis?</td>
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<td>Are all the information sources (databases with dates of coverage, contact with study authors to identify additional studies) described and are the last search day indicated?</td>
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<td>Is the selection process of studies (screening, eligibility, included in systemic review or, if applicable, included in the meta-analysis) described?</td>
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<td>Is the data extraction method from the articles (types of investigations, participants, interventions, analysed factors, indexes) described?</td>
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<td>Are the methods, which were used to evaluate the risk of bias of individual studies and how this information is to be used in data synthesis, described?</td>
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<td>Were the principal summary measures (risk ratio, difference in means) stated?</td>
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<td>Is the number of studies screened: included upon assessment for eligibility and excluded upon giving the reasons in each stage of exclusion presented?</td>
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<td>Are the characteristics of studies presented in the included articles, according to which the data were extracted (e.g., study size, follow-up period, type of respondents) presented?</td>
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<td>17</td>
<td>Are the evaluations of beneficial or harmful outcomes for each study presented? (a) simple summary data for each intervention group; b) effect estimates and confidence intervals</td>
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<td><strong>Discussion (1.4 points)</strong></td>
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<td>Are the main findings summarized and is their relevance indicated?</td>
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<td>Are the limitations of the performed systemic review discussed?</td>
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<td>Does author present the interpretation of the results?</td>
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<td><strong>Conclusions (0.5 points)</strong></td>
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<td>Do the conclusions reflect the topic, aim and tasks of the Master’s thesis?</td>
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<td>Are the conclusions clear and laconic?</td>
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<td><strong>References (1 point)</strong></td>
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<td>Are the links of the references to the text correct?</td>
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<td>Is the scientific level of references suitable for Master’s thesis?</td>
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<td>Do the cited sources not older than 10 years old form at least 70% of sources, and the not older than 5 years – at least 40%?</td>
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<td>Were additional methods of data analysis and their results used and described (sensitivity analyses, meta-regression)?</td>
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<td>Was meta-analysis applied? Are the selected statistical methods indicated?</td>
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<td>Is the thesis volume sufficient (excluding annexes)?</td>
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<td>Does the thesis structure satisfy the requirements of Master's thesis?</td>
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<td>Is the thesis written in correct language, scientifically, logically and laconically?</td>
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<td>37</td>
<td>Are there any grammatical, style or computer literacy-related mistakes?</td>
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<td>38</td>
<td>Is text consistent, integral, and are the volumes of its structural parts balanced?</td>
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<td>39</td>
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<td>Is the content (names of sections and sub-sections and enumeration of pages) in compliance with the thesis structure and aims?</td>
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<td>Are the names of the thesis parts in compliance with the text? Are the titles of sections and sub-sections distinguished logically and</td>
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<td>Are there explanations of the key terms and abbreviations (if needed)?</td>
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<td>Is the quality of the thesis typography (quality of printing, visual aids, binding) good?</td>
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*In total (maximum 10 points):

*Remark: the amount of collected points may exceed 10 points.

Reviewer's comments:
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ABSTRACT

Objectives: The aim of this systematic review was to evaluate in evidence-based way and compare distalization effect in maxillary buccal segment between Palatal Skeletal Anchorage and Zygoma Gear Appliance.

Materials and Methods: Relevant studies were identified by searching in: PubMed, ScienceDirect, AJO-DO and Scopus electronic databases which were available in full-text version, information search for controlled studies on human published between January 1st 2007 till December 30th 2017. Inclusion criteria were: English language, study performed on humans, randomized or non-randomized clinical trials, assessment of buccal segment distalization by Palatal or Zygomatic skeletal anchorage and Patient's clinical preoperative and post-operative evaluation measured by cephalometric analysis. Quality assessment of included studies was performed.

Results: in total 357 scientific publications, articles, clinical trials reviews were identified related to the used keywords during the search. Final amount of 13 articles fulfilled our inclusion criteria's and included in the review.

The results showed that both anchorage systems, were efficient non-extractive treatment alternative for Angle class II malocclusion. Palatal Skeletal Anchorage (PSA) System showed maxillary molar distalization distance range between 1.8mm to 6 mm. Zygoma Gear Appliance (ZGA) presented first molar distalization range of 4.37mm to 5.31mm. Results of maxillary buccal segment distal movement distance, distalization range, duration and anchorage loss or adverse treatment effect rate were evaluated.

Conclusion: Non-extractive therapy alternative by maxillary buccal segment distalization in greater space deficiency then 3 mm was approved. There were evidence that both of skeletal anchorage systemts were effective non-extractive therapy alternative for Angle class II malocclusion, however, ZGA is more effective distalization system compared to PSA.

Keywords: mini implant, TAD, mini screw, skeletal anchorage device, zygomatic anchorage, molar distalization
INTRODUCTION

Maxillary buccal segment distalization, particularly molar distalization, previously was complex treatment approach with unreliable results. Nowadays, thanks to introduction of new anchorage systems, such treatment approach presents successful clinical results and become routine, non-extractive treatment option for Angle class II malocclusion among growing patients.

Over the past centuries, different approaches have been introduced in order to correct Angle Class II malocclusion. Angle Class II malocclusion considered as most frequent orthodontic clinical manifestation among European population, for instance, affecting 25% of children in Denmark [1]. Various treatment approaches differ according the level of facial, dental or skeletal discrepancy. Firstly, skeletal treatment, aimed to engage the functional, skeletal or orthopedic structures of the facial developing skeletal or masticatory system in order to modify the active developing elements while promoting correct skeletal formation prior the growth spurt termination is proposed. Secondly, dental treatment approach, aimed to achieve orthodontic dental corrective effect by engaging dentition in order to promote dental alignment of arch dentition according particular elements which clinically guide for correct maxilla-mandibular relation and correct occlusion formation is applicable [2]. Nevertheless, extractive orthodontic treatment approach suggested in order to correct dental occlusion formation while modifying dental arch space deficiency into correct occlusion establishment by eliminating single or few teeth, unilaterally or bilaterally, thus, incorporate the space for the remaining dentition in order to achieve correct maxilla-mandibular occlusal relationship. The least treatment approach involves corrective jaw surgical therapy which indicated in post-growth spurt individuals in cases when conservative, contemporary skeletal or dental orthodontic treatment may not provide successful and desired clinical results.

Maxillary buccal segment distalization, particularly molar distalization is common non-extractive treatment approach which clinically indicated if skeletal either dentoalveolar protrusion present [3]. Ideally, gaining additional space in order to perform orthodontic correction without extraction is key element for promoting buccal segment distalization. It is a complex procedure which requires application of relatively high, constant force application upon the molar teeth which contribute for correction of maxilla mandibular jaws relation. From biomechanical aspect the main principle of gaining additional space needs engage the maxillary buccal segment dentition and achieve distal bodily movement of the posterior dental region and further anterior region. The clinical success of
the treatment depends upon a variety of factors such as type of treatment application and patient's skeletal developmental stage. Nevertheless, it is a crucial problem to get a combination of orthodontic movement and anchorage stability which together integrated as a complex unit to actively engage the orthodontic force in order to achieve sufficient distalization amount. Influence of posterior dentition such as second or third molar on buccal segment distalization clinical success and rate, yet remain controversial, since previous literature reported that presence of posterior dentition found to have an impact on buccal segment or molar distalization [4]. Nevertheless, other literature have not yet determined whether their presence directly incorporated with distalization effect [3], therefore decision regarding presence of posterior dentition has not fully determined.

Anchorage defined as the ability to minimize undesired tooth, orthodontic movement which generated by any reciprocal force application upon the target tooth [5]. The importance of proper and correct anchorage for high orthodontic force magnitude found to be crucial in order to achieve successful long-term constant high magnitude of force application. The concept of application of relatively high force magnitude upon multi-rooted dentition or a group of teeth, sharing multi-anchorage structural integration within the jaw bone, has potential to generate large variety of adverse orthodontic responses. Force application upon dentition within certain direction, may generate reciprocal forces from the same magnitude to the other side, therefore, those forces should be deflected. Few alternative options exist in order to distort adverse anchorage forces for instance, planning of an indirect anchorage, which involve extrinsic forces application to promote direct anchorage forces stability. Nevertheless, additionally to anchorage stability, accurate force application direction has great impact on success of overall treatment, ideally, maxillary buccal segment distalization rely on principle of bodily movement with tipping free while preserving the force direction as close as possible to center of resistance of the target dentition.

Previously, few anchorage approaches has been introduced. Firstly, an extra-oral anchorage, particularly the Headgear device which considered as first significant treatment option of dental or skeletal Class II malocclusion was proposed. This method involved extra-oral mask or strap, resting on skull bones or neck region together with intraoral bow engaging unilateral or bilateral maxillary molars by application of 450gr of force. Successful clinical result by correcting into Class I, achieved by estimated period of approximately 9 months [6]. However, the main disadvantage of such anchorage involves complete treatment compliance and patient's co-operation factor, by device
caring the recommended daily time period. In fact, such device has a great impact on patient either esthetically, socially and psychologically which eventually affect overall treatment success rate. Patient compliance factor encouraged further investigations and discover of non-compliance anchorage systems in order to promote high force magnitude and eliminate the treatment compliance from patients [7].

Conventional anchorage with intraoral distalizing appliances, which were introduced in the 1980s [8], provided a solution in order to eliminate patients compliance factor and promote treatment efficiency and success, nevertheless, improvement of patients self-esteem and facial esthetics contributing for patients co-operation. Intraoral anchorage provides a large variety of appliances which can be modified structurally according clinical characteristics. Main principle in molar distalization is adjustment of palatal surface anchorage and force generation by application primarily towards premolars and molars respectively. However, previous studies found that conventional intraoral anchorage for maxillary molar distalization, found to have significant high amount of anchorage loss [7], and particularly maxillary premolar mesial inclination, incisors intrusion as an adverse response in addition to potential relapse using first molar as active anchorage element [8].

Skeletal anchorage, by the meaning of bone level force origin temporary anchorage element, has become a routine approach of contemporary orthodontics’. Temporary anchorage devices (TAD), providing clinicians to perform whether direct or indirect anchorage while preserving force application constantly without patients' compliance. Historically, the concept of temporary anchorage has been first documented on the 1980's by applying screw upon alveolar ridge to promote dentition stability [9]. Few skeletal anchors devices has been previously recorded, such as ossteointegrated implants, mini-implants, mini-screws and mini-plates, Nevertheless, skeletal anchors highly used in addition to conventional anchorage distalizers, in order to promote reinforcement and modify devices' stability with reduction of anchorage loss potential. Previous studies and meta-analyses found that skeletal anchorage on maxillary molar distalization, presented significantly reduced anchorage loss compared to conventional intraoral anchorage [7]. In order to engage maxillary buccal segment for distalization, few locations of skeletal zone has an impact on maxillary buccal segment distalization.

Firstly, Palatal Skeletal Anchorage (PSA) location, represents a group of anchorage locations which
utilize anterior palatal zone or premaxilla zone adjacent to, and in front of maxillary suture, which presented as indirect, non-surgical skeletal temporary anchorage location method. PSA utilizes a single or few temporary anchorage devices by the meaning of mini-implant or mini-screws with size range between 2-2.3 mm in diameter and 9 mm in length, located within the T-zone which is located posteriorly to the third palatal rugea [10]. Such anchorage aimed to engage maxillary buccal segment in a combination with modified conventional intraoral distalizing appliance which extends posteriorly attaching both first molars and premolars with skeletal anchorage reinforcement which contribute by reciprocal forces and distribution along the palate. Another PSA positive fact is safe distance from maxillary incisors together with thin mucous membrane surrounding the mini-implant while preserving its proper stability during force application, nevertheless, easy mini-implant insertion location and its incorporation with intraoral distalizer device, found to be convenient for the clinician's treatment planning and application. However, mini-implant location in addition to bulky appliances, clinically manifest by patients' lack of convenience and undergoing strict oral hygiene regimen which may contribute for additional adverse intraoral tissues adverse reaction.

Zygoma Gear Appliance (ZGA) or by other name Zygoma Anchorage System (ZAS), is relatively new anchorage system which has been introduced by Nur et al and Sugawar [8,11]. Such anchorage utilizes direct anchorage using mini-plate with three integrated mini-screws on zygomatic buttress applied surgically. The zygomatic buttress may contribute for increased skeletal anchorage structural stability, by larger skeletal anchorage surface utilization, accompanied with higher force generation upon target dentition in addition to significantly less bulky intraoral devices presence. Nevertheless, the surgical approach of mini-plate application, found to have soft-tissue inflammation potential, therefore, patients' proper oral hygiene, in addition to routine follow-up appointment, is crucial for ZGA success.

The inter-radicular site, considered as direct non-surgical method, described as application of smaller diameter mini-screws applied in between maxillary teeth roots. Inter-radicular anchorage, previously and nowadays is common anchorage choice among clinicians, however, presence of thick vestibular gingiva in addition to the close proximity to maxillary dentition roots may jeopardize the dentition condition, or potential to have mini-screw and root contact, may result in screw failure [9].
Previous literature demonstrated, regarding greater discrepancy of 3 mm space per side will require orthodontic extractive therapy [12]. The aim of this systematic review is to evaluate in evidence-based way and compare between Palatal Skeletal Anchorage and Zygoma Gear Appliance distalization effect in maxillary buccal segment.

Our tasks are:

1. To compare and evaluate the dentoskeletal changes and amount of maxillary buccal segment distalization and treatment duration between Palatal Anchorage distalizers and Zygoma Gear Appliance
2. To evaluate whether it is possible to gain more than 3 mm buccal segment distalization under non-extractive therapy with skeletal anchorage methods.
3. To compare anchorage failure and adverse reactions between indirect distalization anchorage and direct distalization anchorage.
SELECTION CRITERIA OF THE STUDIES.
SEARCH METHOD AND STRATEGY

The systematic review conducted according the protocol of following PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) statement [13].

The literature, systematic review is based on an identification selection of main information source literature studies conducted from electronic databases which used during search in Google web browser. The keywords that have been used during search are: mini implant, TAD, mini screws, skeletal anchorage device, zygomatic anchorage and molar distalization.

The relevant literature studies were identified by searching in PubMed, Science Direct, AJO-DO and Scopus electronic databases, data were analyzed and decided whether to include in the systematic review.

The literature search include evaluation of scientific articles from dental journals which were in English language, studies performed on humans and publication dates limit within period from January 1st, 2007 till December 30th 2017 in addition to the included selected keywords. In total 357 scientific publications, articles, clinical trials reviews were identified and were related to keywords that were used during the search.

Titles and abstracts which derived from the broad search were independently screened to eliminate irrelevant publications. The final stage of screening involves full-text articles review and reading in order to certify study eligibility upon inclusion and exclusion criteria (Table 1).

<table>
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<tr>
<th>Component</th>
<th>Description</th>
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<tr>
<td>Population</td>
<td>Patients with dental Angle Class II malocclusion treated with non-extractive therapy</td>
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<tr>
<td>Intervention</td>
<td>Maxillary buccal segment or molar distalization devices</td>
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<tr>
<td>Comparison</td>
<td>Palatal Anchorage and Zygoma gear appliance</td>
</tr>
<tr>
<td>Outcome</td>
<td>Changes in distalization amount, treatment duration and anchorage failure or adverse effect.</td>
</tr>
<tr>
<td>Study design</td>
<td>Randomized and non-randomized controlled comparative trials</td>
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The articles which were included within the study all records had to be determined by the following inclusion criteria:

1. Patient's clinical preoperative and post-operative evaluation measured by cephalometric analysis.
2. Treatment of buccal segment distalization performed by Palatal or Zygomatic skeletal anchorage.
3. All study subjects are humans.
4. Years of articles publication were limited to period from January 1st, 2007 till December 30th 2017.

The exclusion criteria were:

1. In vitro studies.
3. Literature reviews, single case reports, editorials, commentaries.
4. Non-scientific topic irrelevancy.

Majority of the studies selected for the systematic review were published on:

- American Journal of Orthodontics and Dentofacial Orthopedics- [www.ajodo.org](http://www.ajodo.org)
- The Angle orthodontics- [www.angle.org](http://www.angle.org)
SYSTEMATIZATION AND ANALYSIS OF DATA

The article search and data extraction according to the PRISMA flow diagram [13] presented in Figure 1. The full search strategy is presented in Annex 1. The initial database search displayed 357 results. The preliminary exclusion was done by topic relevancy; 65 duplicated titles and abstracts were excluded. From the remaining 292 articles results, 72 presented case reports, 6 were beyond dates limit and other 184 were excluded due to other exclusion reasons. 28 full-text articles were assessed for eligibility. Finally, 13 articles were included in the review.

PubMed, ScienceDirect, AJO-DO, Scopus database advanced search
- Search terms: "mini implant" OR "TAD" OR "mini screw" OR "skeletal anchorage device" OR "zygomatic anchorage" AND "molar distalization"
- English language
- Studies on human
- Dental journals

(n = 357)

Records after duplicates removed
(n = 292)

Records screened
(n = 30)

Full-text articles assessed for eligibility
(n = 28)

Studies included in qualitative synthesis
(n = 13)
- Palatal Skeletal Anchorage (9)
- Zygoma Gear Appliance (4)

Removed duplicated titles and abstracts
(n = 65)

Exclusion criteria:
- case reports (n = 72)
- Year (n = 6)
- Other (n = 184)

Full-text articles excluded, with reasons
- no access (n = 2)

Full-text articles excluded due to other reasons:
- study type (n = 1)
- inadequate analysis assessment (n = 6)
- Additional methodology filtration (n = 8)

Figure 1. PRISMA flow diagram
Assessment of methodological quality

The quality of included studies performed during data analysis process and involved methodological quality evaluation of study elements which may influence each individual study outcome. The assessment performed by two different evaluation methods which evaluate the study quality in different scientific objective level. The Cochrane hand book for assessing risk of bias [14], used to assess bias across the studies in order to identify study and methodological flaws. Based on the data given in each study potential risk of bias categorized into: low risk of bias (+), unclear risk of bias (?), or high risk of bias (-) (Table 2). The quality assessment of included studies revealed an unknown risk of bias (for one or more key domains) for the majority of the included studies [15-20, 22-26] two studies [6, 21] were classified as high risk of bias (one of more key domains).

Table 2. Risk of Bias Summary

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<th>Author</th>
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<th>Blinding of outcome assessment</th>
<th>Incomplete outcome data addressed</th>
<th>Selective reportin g</th>
<th>Other bias</th>
</tr>
</thead>
<tbody>
<tr>
<td>Escobar et al.</td>
<td>?</td>
<td>?</td>
<td>+</td>
<td>+</td>
<td>-</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Oberti et al.</td>
<td>?</td>
<td>?</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Kinzing et r. [19]</td>
<td>?</td>
<td>?</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>?</td>
</tr>
<tr>
<td>Polat-Ozsoy et</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Nienkemin per.[21]</td>
<td>-</td>
<td>?</td>
<td>?</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Gelgor et al.</td>
<td>?</td>
<td>?</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Onçag et al.</td>
<td>?</td>
<td>?</td>
<td>?</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Nur et al. [25]</td>
<td>?</td>
<td>?</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Kilkis. [26]</td>
<td>?</td>
<td>?</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td>Kaya. [6]</td>
<td>-</td>
<td>?</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>
Quality analysis

Study quality has been performed due to incomplete applicability on the non-randomized clinical trials and unclear or lack of evidence regarding the placebo appearance and patients or observers' blinding methods to the scaled quality assessment. Instead, the quality of the articles has been scored according a scoring system which was suggested by Feldmann [5], the methodological quality scoring protocol described in Table 3, according methodological criteria's', the studies were scored as low, medium or high. The scoring factors are; study type and scientific level of the study, amount of study participants, adequate description provided regarding participants selection, clear explanation regarding methodological results analyzation, statistical evaluation and randomization of statistical error and presence of any confounding factors which may contribute for reduced study quality. Most of the studies sharing same drawbacks, according our criteria used, main study quality scoring found to be low methodological study quality.

Table 3. Methodological quality scoring protocol

<table>
<thead>
<tr>
<th>1. Study design</th>
</tr>
</thead>
<tbody>
<tr>
<td>• High: Randomized control trial</td>
</tr>
<tr>
<td>• Moderate: Prospective comparative study</td>
</tr>
<tr>
<td>• Low: Retrospective comparative</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>2. Sample size</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Adequate: N≥15</td>
</tr>
<tr>
<td>• Inadequate: N&lt;15</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>3. Selection description</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Adequate: description of all required items (age, gender, class II malocclusion severity)</td>
</tr>
<tr>
<td>• Partially inadequate: 2 items description</td>
</tr>
<tr>
<td>• Inadequate: 1 item description</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>4. Valid measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Yes: present</td>
</tr>
<tr>
<td>• No: absent</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>5. Method error analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Yes: present</td>
</tr>
<tr>
<td>• No: absent</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>6. Adequate statistics provided</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Yes: present</td>
</tr>
<tr>
<td>• No: Absence</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>7. Confounding factors</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Yes: negative value</td>
</tr>
<tr>
<td>• No: positive value</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>8. Overall judgment</th>
</tr>
</thead>
<tbody>
<tr>
<td>• High: less than 1 negative value</td>
</tr>
<tr>
<td>• Moderate: 2 negative values</td>
</tr>
<tr>
<td>• Low: 3 and more negative values</td>
</tr>
</tbody>
</table>
A quality analysis of the 13 articles involved is summarized in Table 4. Seven out of the thirteen studies scored as low quality, other 6 scored as moderate quality level. No high study quality has been determined. The most prominent drawback was prospective comparative study with absence of measurement methodological description in addition to absence of blinding in measurement and problem of confounding factors. All of the studies sharing same methodological assessment of maxillary molar or buccal segment distalization, however, neither on were using blinding in measurements, two studies inadequate participants, seven studies did not include either method of statistical error analysis.
<table>
<thead>
<tr>
<th>Author, year</th>
<th>Study design</th>
<th>Sample size</th>
<th>Selection description</th>
<th>Valid measurement methods description</th>
<th>Method Error Analysis</th>
<th>Blinding in measurements</th>
<th>Adequate statistics provided</th>
<th>Confounding factors</th>
<th>Judged quality standard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kaya. [15]</td>
<td>Retrospective</td>
<td>Adequate</td>
<td>Adequate</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Moderate</td>
</tr>
<tr>
<td>Su-Jung Mah. [16]</td>
<td>Prospective comparative</td>
<td>Inadequate</td>
<td>Inadequate</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Low</td>
</tr>
<tr>
<td>Escobar et al. [17]</td>
<td>Prospective comparative</td>
<td>Adequate</td>
<td>Adequate</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Low</td>
</tr>
<tr>
<td>Oberti et al. [18]</td>
<td>Prospective comparative</td>
<td>Adequate</td>
<td>Adequate</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Low</td>
</tr>
<tr>
<td>Kinzinger. [19]</td>
<td>Retrospective</td>
<td>Inadequate</td>
<td>Adequate</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Low</td>
</tr>
<tr>
<td>Polat-Ozsoy et al. [20]</td>
<td>Retrospective comparative</td>
<td>Adequate</td>
<td>Adequate</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Low</td>
</tr>
<tr>
<td>Nienkemper. [21]</td>
<td>Retrospective</td>
<td>Adequate</td>
<td>Adequate</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Moderate</td>
</tr>
<tr>
<td>Gelgor et al. [22]</td>
<td>Prospective comparative</td>
<td>Adequate</td>
<td>Adequate</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>Yes, Not described cephalometric auxiliary method</td>
<td>Low</td>
</tr>
<tr>
<td>Authors</td>
<td>Study Design</td>
<td>Data Adequacy</td>
<td>Outcome Adequacy</td>
<td>Treatment Adequacy</td>
<td>Bias Adequacy</td>
<td>Funding Adequacy</td>
<td>Overall Adequacy</td>
<td>Study Quality</td>
<td></td>
</tr>
<tr>
<td>------------------</td>
<td>-------------------------</td>
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<td>------------------</td>
<td>--------------------</td>
<td>---------------</td>
<td>------------------</td>
<td>------------------</td>
<td>---------------</td>
<td></td>
</tr>
<tr>
<td>Önçag et al. [23]</td>
<td>Prospective comparative</td>
<td>Adequate</td>
<td>Adequate</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Moderate</td>
</tr>
<tr>
<td>Sa’aed. [24]</td>
<td>Retrospective comparative</td>
<td>Adequate</td>
<td>Adequate</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Low</td>
</tr>
<tr>
<td>Nur et al. [25]</td>
<td>Prospective comparative</td>
<td>Adequate</td>
<td>Adequate</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Moderate</td>
</tr>
<tr>
<td>Kilkis. [26]</td>
<td>Prospective comparative</td>
<td>Adequate</td>
<td>Adequate</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Moderate</td>
</tr>
<tr>
<td>Kaya. [6]</td>
<td>Prospective comparative</td>
<td>Adequate</td>
<td>Adequate</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
<td>Moderate</td>
</tr>
</tbody>
</table>
1. EVALUATION OF PALATAL ANCHORAGE IN MAXILLARY 
BUCCAL SEGMENT DISTALIZATION

The included studies were compared according to maxillary buccal segment distalization evaluation by the two skeletal anchorage locations regarding to the study type, amount of participants, mini-implant or mini-screws company, amount of mini-implants utilized and distalization appliance used and reported anchorage loss or treatment adverse effect. Treatment effect of skeletal distalizers was assessed in 16 groups which were analyzed in 13 studies totally. Nine studies represented the Palatal Skeletal Anchorage and 4 studies represented Zygoma Anchorage System; one study was included in both groups since it compares both of the methods [15]. The included studies characteristics presented in Table 5. Palatal Anchorage distalizers involved 12 groups within 10 studies and Zygoma Anchorage System described in 4 selected studies.

Evaluation of beneficial or harmful outcomes for each study group is not entirely possible to be evaluated due to the fact that entirely involved study groups are part of comparative, non-randomized clinical trials which eliminate the access for sampling data exposure by the authors. Nevertheless, our selected studies, which are prospective and retrospective non-randomized clinical trials, are investigating the particular results of involved study groups and presenting the results outcomes of the particular evaluated findings.

Palatal Anchorage evaluation composed of eight skeletal anchored distalizing appliances. The most common appliance which utilized indirect skeletal anchorage in premaxillary zone is the pendulum device with its modification variations (5 groups) [15-17, 20, 23], other appliances used were modified palatal arch, Dual-force, Distal-jet, Beneslider, Removable Nance holding arch, Modified Nance holding arch and modified palatal bar. Seven studies out of ten, utilized two mini-implants which were inserted in paramedian region or region of the maxillary mid-palatal suture and were applied by 230-300g force magnitude. In the studies done by Kinzinger et al and Niekmper [19, 2], force presented by 200cN and 2.4N respectively. Force magnitude was not presented in both of study groups of the single article [18]. Single mini-implant anchorage in anterior mid-palatal region was used in two articles of three study groups [22, 23] which generated 250-300g of force; 3 mini-screws connected to palatal bar with 2 hooks which generated anchorage for 300g of force presented in one study [24]. Adverse treatment effect and anchorage loss during active distalization using Palatal Skeletal Anchorage, reported in 5 studies [17, 20-22, 24] involves loss of screw...
osseous stability and evidence of screw mobility [17, 20, 21], soft tissue inflammation around mini-implant [17, 24], slight incisors proclination and increased overjet in addition to molar rotation and mesial tipping of premolars which resulted in overall treatment failure [22] and pendulum appliance spring breakage [20]. The skeletal anchorage evaluation composed of 7 mini-implants or mini-screws companies. The most used company was Stryker, Leibinger, [15, 20, 23], following other Mondeal Medical systems [17, 21], JeilMedical [20, 24], Forestadent, Camlog Biotechnologies. PSM medical solutions, represented by the largest participant study, which consist of 51 participants described in Nienkemper's study. [21].

Table 5. Characteristics of included studies

<table>
<thead>
<tr>
<th>Num</th>
<th>Author and year</th>
<th>N</th>
<th>Mini-implant company</th>
<th>Amount of mini-implants</th>
<th>Appliance</th>
<th>Force</th>
<th>Anchorage loss and adverse effect</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Kaya. 2012 [15]</td>
<td>15</td>
<td>Stryker, Leibinger, Germany</td>
<td>2</td>
<td>Implant-Supported Pendulum device</td>
<td>230g</td>
<td>Not reported</td>
</tr>
<tr>
<td>2.1</td>
<td>Su-Jung Mah. 2016 [16]</td>
<td>7</td>
<td>Not reported</td>
<td>2</td>
<td>Lingual (palatal)arch</td>
<td>-</td>
<td>Not reported</td>
</tr>
<tr>
<td>2.2</td>
<td>Su-Jung Mah. 2016 [16]</td>
<td>7</td>
<td>Not reported</td>
<td>2</td>
<td>Pendulum</td>
<td>-</td>
<td>Not reported</td>
</tr>
<tr>
<td>3</td>
<td>Escobar et al. 2007 [17]</td>
<td>15</td>
<td>Mondeal Medical Systems, Germany</td>
<td>2</td>
<td>Modified pendulum</td>
<td>250g</td>
<td>2 evidence of inflammation and screw failure</td>
</tr>
<tr>
<td>4</td>
<td>Oberti et al. 2009 [18]</td>
<td>16</td>
<td>Mondeal Medical Systems, Germany</td>
<td>2</td>
<td>Dual-Force</td>
<td>250-300 g</td>
<td>Not reported</td>
</tr>
<tr>
<td>5</td>
<td>Kinzinger. 2009 [19]</td>
<td>10</td>
<td>Forestadent, JeilMedical, South Korea</td>
<td>2</td>
<td>Distal jet coil-spring systems</td>
<td>200 cN</td>
<td>Not reported</td>
</tr>
<tr>
<td>6</td>
<td>Polat-Ozsoy et al. 2008 [20]</td>
<td>22</td>
<td>Stryker, Leibinger, Germany</td>
<td>2</td>
<td>Bone-anchored pendulum appliance</td>
<td>230g</td>
<td>1 case of pendulum spring breakage, 1 screw found unstable, 3</td>
</tr>
<tr>
<td></td>
<td></td>
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<td>------------------------</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Nienkemp er. 2014 [21]</td>
<td>51</td>
<td>PSM medical solutions, Germany</td>
<td>2</td>
<td>Beneslider appliance</td>
<td>2.4N</td>
<td>2 mini-implants-slightly mobile after device removal</td>
</tr>
<tr>
<td>8.1</td>
<td>Gelgor et al. 2007 [22] Group 1</td>
<td>20</td>
<td>Stryker, Leibinger, Germany</td>
<td>1</td>
<td>Removable Nance holding arch</td>
<td>250g</td>
<td>Slight incisors proclination, increased overjet, molar rotation and mesial tipping of premolars</td>
</tr>
<tr>
<td>8.2</td>
<td>Gelgor et al. 2007 [22] Group 2</td>
<td>20</td>
<td>Stryker, Leibinger, Germany</td>
<td>1</td>
<td>Modified Nance holding arch</td>
<td>250g</td>
<td>Not reported</td>
</tr>
<tr>
<td>9</td>
<td>Önçag et al, 2007. [23]</td>
<td>15</td>
<td>Camlog Biotechnologies Basel Switzerland</td>
<td>1</td>
<td>Pendulum</td>
<td>300g</td>
<td>Not reported</td>
</tr>
<tr>
<td>10</td>
<td>Sa’aed. 2014 [24]</td>
<td>24</td>
<td>Jeil Corporation, Seoul, Korea</td>
<td>3</td>
<td>Palatal bar with two hooks</td>
<td>300g</td>
<td>3 cases of soft tissue inflammation</td>
</tr>
</tbody>
</table>

### Zygoma Gear Appliance

<p>| | | | | | | |</p>
<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Nur et al. 2012 [25]</td>
<td>15</td>
<td>MPI 1000, Turkey</td>
<td>3</td>
<td>Miniplate + Modified Headgear intraoral bow with Ni-Ti closed coil spring</td>
<td>300g</td>
</tr>
<tr>
<td>2</td>
<td>Kilkis. 2016 [26]</td>
<td>21</td>
<td>MPI 1000, Turkey</td>
<td>3</td>
<td>Miniplate + headgear intraoral U-bow with coil spring</td>
<td>350g</td>
</tr>
<tr>
<td>3</td>
<td>Kaya.</td>
<td>15</td>
<td>Surgi-Tec,</td>
<td>3</td>
<td>Miniplate +</td>
<td>450g</td>
</tr>
</tbody>
</table>
Cephalometric results evaluation and comparison between the methods described in Table 6. Comparative evaluation performed regarding participants mean age presentation, first molar distalization amount by mm and tipping degree, second premolar or first premolar distalization and tipping, distalization rate per month and overall treatment duration until molar Class I correction achieved. The mean chronologic age ranges from 11.6 [22] to 19.2 [16], mean initial age was not reported in one study [23]. Mean molar distal movement ranges from 1.8mm [16] to 6mm [17], mean distal tipping of the molar ranges from 0.75° [22] to 11.3° [17]. Premolars mean distalization range from 1.83mm [15] to 4.85 mm [17] and mean distal tipping from 3° [19] to 9.9° [20]. One article with two study groups reported mesial premolar tipping of 3.15° and 0.10° [22]. The overall distalization duration ranged from 4.6 months [22] to 28 months [24]. The greatest distalization amount used PSA with implant supported pendulum device reported by Escobar et al [17], which consisted of 15 participants, achieved molar distalization of 6±2.27mm and first molar tipping of 11.3±6.2°. The premolars distalized by 4.85±1.96mm and tipped distally 8.6±5.08°, overall treatment duration until Class I correction 7.8±1.7 months. In the study done by Gelgor et al, [22] premolar mesial tipping in both of the study groups with mean value of 3.15° and slight degree of 0.10° which indicates anchorage loss. Premolar distalization amount and tipping was not described in 4 articles out of 10 [16, 21, 24], premolar distalization amount individually, was not reported in one study [22]. Distalization rate report was absent in six articles [16, 17, 19, 22-24] and treatment duration indication was absent in one article. [16]
<table>
<thead>
<tr>
<th>Num</th>
<th>Mean Age (y)</th>
<th>Molar distalization (mm)</th>
<th>Molar tipping (°)</th>
<th>Distalization rate (mm/month)</th>
<th>Premolar movement (mm)</th>
<th>Premolar tipping (°)</th>
<th>Treatment duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>14.3±1.6</td>
<td>3.00±1.70</td>
<td>8.80±6.54</td>
<td>0.1–0.37</td>
<td>1.83±1.14</td>
<td>6.10±5.80</td>
<td>8.1±4.2 months</td>
</tr>
<tr>
<td>2.1</td>
<td>19.2±4.4</td>
<td>2.4±3.1</td>
<td>0.8 ± 2.0</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>2.2</td>
<td>19.2±4.4</td>
<td>1.8 ± 1.2</td>
<td>1.5 ± 1.3</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>13±2.1</td>
<td>6±2.27</td>
<td>11.3±6.2</td>
<td>-</td>
<td>4.85±1.96</td>
<td>8.6±5.08</td>
<td>7.8±1.7 months</td>
</tr>
<tr>
<td>4</td>
<td>14.3</td>
<td>5.9±1.7</td>
<td>5.6±3.7</td>
<td>1.2</td>
<td>4.26±1.9</td>
<td>5.4±3.8</td>
<td>5 months</td>
</tr>
<tr>
<td>5</td>
<td>12.1</td>
<td>3.92±0.53</td>
<td>2.79±2.51</td>
<td>-</td>
<td>1.87±0.74</td>
<td>3.00±2.69</td>
<td>6.7 months</td>
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<tr>
<td>6</td>
<td>13.61±2.0</td>
<td>4.8±1.8</td>
<td>9.1±4.6</td>
<td>0.7</td>
<td>4.1±2.1</td>
<td>9.9±5.2</td>
<td>6.8±1.7 months</td>
</tr>
<tr>
<td>7</td>
<td>17.8±9.6</td>
<td>3.6±1.9</td>
<td>1.5±6.7</td>
<td>0.6±0.4</td>
<td>-</td>
<td>-</td>
<td>7.5±2.9 months</td>
</tr>
<tr>
<td>8.1</td>
<td>11.6-15.1</td>
<td>3.95±1.68</td>
<td>9.05±4.67</td>
<td>-</td>
<td>-</td>
<td>-3.15±3.36</td>
<td>4.6 months</td>
</tr>
<tr>
<td>8.2</td>
<td>12.3-15.4</td>
<td>3.88±1.47</td>
<td>0.75±0.72</td>
<td>-</td>
<td>-</td>
<td>-0.10±0.38</td>
<td>5.4 months</td>
</tr>
<tr>
<td>9</td>
<td>-</td>
<td>3.4±1.18</td>
<td>10±3.2/9</td>
<td>-</td>
<td>2.08±0.94</td>
<td>7.26±4.54</td>
<td>27 weeks (6.75 months)</td>
</tr>
<tr>
<td>10</td>
<td>12.4</td>
<td>3.06±0.54</td>
<td>1.53±0.98</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>28.0 ± 8.2 months</td>
</tr>
<tr>
<td></td>
<td>15.87±1.09</td>
<td>4.37±2.15</td>
<td>3.30±2.31</td>
<td>0.84</td>
<td>-</td>
<td>-</td>
<td>5.21±0.96 months</td>
</tr>
<tr>
<td>---</td>
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<td>------</td>
<td>---</td>
<td>---</td>
<td>-----------------</td>
</tr>
<tr>
<td>2</td>
<td>15.68±2.18</td>
<td>5.31±2.45</td>
<td>6.39±5.39</td>
<td>0.98</td>
<td>1.63±1.90</td>
<td>4.05±3.47</td>
<td>0.45±0.12 years</td>
</tr>
<tr>
<td>3</td>
<td>14.7±2.5</td>
<td>5.03±0.30</td>
<td>5.43±1.36</td>
<td>0.5–0.6</td>
<td>4.80±0.27</td>
<td>2.00±1.56</td>
<td>9.0±2.4 months</td>
</tr>
<tr>
<td>4</td>
<td>14.74±0.65</td>
<td>5.27±1.53</td>
<td>5.77±4.99</td>
<td>-</td>
<td>5.17±1.52</td>
<td>2.27±5.70</td>
<td>9.03±0.62 months</td>
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2. EVALUATION OF ZYGOMA GEAR APPLIANCE IN MAXILLARY BUCCAL SEGMENT DISTALIZATION

For evaluation of Zygoma Gear Appliance skeletal and dental effect in maxillary buccal segment distalization 4 articles and study groups dealing with ZGA or ZAS were included. Evaluated studies characteristics presented in Table 5. The study performed by Nur et al [25] specified bilateral buccal segment distalization results, 2 comparative clinical studies were performed, between ZGA and Palatal Skeletal Anchorage [15] and Cervical Headgear [6]; one study was presented indicating clinical results of unilateral molar distalization [26]. All the studies sharing same amount of 3 mini-screws utilization in a combination with mini-plate applied in surgical manner. The following appliances attached to the mini-plates: Modified Headgear intraoral bow with Ni-Ti closed coil spring, headgear intraoral U-bow with coil spring, round bar, and a cylindrical terminal unit, Distal bent cylindrical unit with Ni-Ti closed coil spring. The largest amount of participants was presented in the study done by Kilkis [26], other 3 articles analyzed same amount of 15 participants. The active force load range between 300g [25] to 450g [15, 6]. Three skeletal anchorage mini-plate companies were introduced in the articles, MPI 1000 [25, 26], Surgi-Tec [15, 6], Bollard [6]. Four cases of adverse treatment effect reported in 2 studies which involve zygomatic mini-plate infection and gingival inflammation.

The included studies cephalometric results of ZGA comparative evaluation described in Table 6. The comparative evaluation performed regarding participants mean age presentation, first molar distalization distance by millimeters and tipping degree, second premolar or first premolar distalization and tipping, distalization rate per month and overall treatment duration until Class I correction achieved. Mean initial chronologic age ranged from 14.7 [15] to 15.87 [25] years. The mean molar distal movement ranged from 4.37mm [25] to 5.31mm [26], and the mean molar distal tipping ranged from 3.3̊ [25] to 6.39̊ [26]. The greatest molar distalization distance amount was reported by Kilkis et al [26] which evaluated the dental and skeletal effect of unilateral molar distalzation utilizing ZGA, the presented molar distalization reported 5.31mm with distalization rate of 0.98mm per month, 6.39̊ of molar distal tipping, premolar distalized by 1.63 mm and distally tipped 4.05̊. Overall mean treatment duration until Class I correction reported 4.5 months. Distalization rate reported from 0.5mm per month [15] to 0.98mm per month [26]. One study not presented distalization rate [6]. Premolar distal movement
ranged from 1.63mm [26] to 6.17mm [6]. Premolar distal tipping range reported between 2° [15] to 4.05° [26]. In the study done by Nur et al [25] premolar distalization distance and tipping degree was not reported. Overall treatment duration until Class I achievement ranged from 4.5 months [26] to 9.03 months[6].
DISCUSSION

Our systematic review evaluated and compared distalization effect and efficiency between 2 contemporary skeletal anchorage locations. The Palatal Skeletal anchorage location, previously proved its effectiveness in maxillary molar distalization with 89.1% success rate which is statistically significant greater compared to other methods used, for instance, buccal inter-radicular, which found to be 71% success rate [27]. The Zygomatic Anchorage System, which has been introduced by Sugawara and Nur et al [8,11] relatively new surgical anchorage method which has been introduced as an alternative, surgical method of orthodontic skeletal anchorage method utilizes zygomatic buttress in order to facilitate reinforced anatomical skeletal platform contributing for increased effective anchorage support and greater segmental distalization, rather than single tooth distalization, particularly maxillary first molar.

Previous literature demonstration, regarding clinical priority of extractive orthodontic therapy involved greater space discrepancy than 3 mm in Angle Class II malocclusion, was rejected. Both skeletal anchorage sites, achieved successful distal movement of either first molar, either buccal segment greater than 3 mm, contributing for sufficient space gaining in order to align dentition within the dental arch and correct Angle Class II malocclusion.

Based on our evaluation analysis results, we discovered that majority of routinely performed PSA utilized double paramedian mini-implant anchorage, the greatest segmental distalization reported in 2 studies which utilized 2 paramedian mini-implants in a combination with modified pendulum appliance and dual-force intraoral appliance [18,19]. Both of the studies used Mondeal Medical Systems Mini-implant Company, the anchorage load reported by 250-300g of force which successfully displaced the buccal segment distally by 6mm and 5.9mm with distal first molar tipping of 11.3° and 5.6° respectively, premolar distalization reported by 4.86 mm and 4.26mm with distal tipping of 8.6° and 5.4° respectively. However, although sufficient distalization force application is crucial element for sufficient distalization amount, excessive distal tipping degree indicate excessive force application distant from dentition center of resistance, nevertheless, successful distalization considered by sufficient desired amount of distal bodily movement of target dentition together with minimal tipping degree in addition to minimal anchorage loss presentation. Intraoral reinforcement appliance design is a crucial element in overall distalization success.
Previous meta-analysis discovered that conventional intraoral anchorage characterized by anchorage relies on intraoral anatomical landmark had success rate of 82% of molar distalization and 69% of premolar distalization [7]. The most common used conventional skeletal anchorage appliance was the skeletal modified pendulum appliance which used in 6 out of 10 studies, the appliance design significance is high since distalization activation play major role in distalization forces vector and activation rate. However, main drawback represented anchorage loss which clinically manifests by reciprocal premolar mesial tipping. Skeletal anchorage, utilizes conventional intraoral appliances as reinforcement or indirect anchorage characteristics, due to the fact that skeletal anchorage found to have decreased rate of anchorage loss [7]. Nevertheless, mechanical disadvantage of conventional anchorage appliances, which utilized indirect skeletal anchorage reinforcement solution, do not totally diminishing anchorage loss and reciprocal orthodontic forces upon dentition target dentition. Based on our analysis we discovered that one article identified anchorage loss by the meaning of mesial premolar tipping of 3.15° [22] in addition to increased incisors proclination, increased overjet and appearance of first molar rotation. The fact that single mini-implant loaded by 250g of force may contribute for increased potential of acting reciprocal forces distribution along the loaded target dentition, represented by overload, result in undesired dentition formation.

Based on our overall analyzed cephalometric results, we discovered that both of skeletal anchorage distalizing systems were effective in buccal segment distalization in relation of distal displacement of maxillary first molar as one by one distalization or buccal segment distalization as En-Masse distalization. However, the cephalometric results indicating that Palatal Skeletal Anchorage study group's results were less consistent and having relatively large prospective difference range within all evaluating parameters compared to Zygoma Gear Appliance evaluation which show more consistent results indicating more effecting distalization system. Therefore, both of the systems found successfully distalize greater distance than 3mm in maxillary buccal segment. Nevertheless, we found that ZGA, is effective treatment alternative to extractive orthodontic treatment in order to correct Angle Class II malocclusion, since all study groups presented greater distalization results of maxillary buccal segment, particularly first molar, greater distalization distance than 3 mm either unilateral, either bilateral distalization.
Our systematic review evaluated 13 articles which involved eleven unknown risk of bias and two articles were classified as high risk of bias. Regarding methodological quality, based on Feldmans' scaling evaluation and our scoring decision, we discovered seven articles were scored as low quality and six articles scored moderate quality level, no articles have been scored as high quality. All study types evaluated in this systematic review found to be prospective comparative clinical trials or retrospective comparative clinical trials. The most powerful scientific tool for high quality clinical evaluation and comparison is randomized clinical trials; so far lack within involved study types dealing with our issued topic. More randomized trials should be conducted in order to promote higher level of temporary skeletal anchorage distalizers effect evaluation in order to clearly conclude what distalization system proved it effectiveness in buccal segment distalization together with minimization of anchorage failure and adverse treatment responses. Nevertheless, comparative evaluative obstacle is the fact that different cephalometric evaluation auxiliaries' references have not been following the same evaluation method. For instance, some part of the authors used the pterygopalatine process as vertical reference while other part used the sella turcica. Also, different horizontal auxiliary references found to be involved by the authors. However, the main clinical comparative evaluation factor is measured difference before and after the treatment which present by millimeters for distance and degrees for tipping, has been investigated within our comparative analysis.

Patients comfort factor is a crucial element for treatment success, in comparison between the groups we may identify some few important factors which may be taken in consideration in order to improve clinical success, The PSA, rely on basic principle of utilizing single or few skeletal anchorage devices which located in center and anterior of the palate, in addition to presence of bulky intraoral anchorage device which engages on target dentition. Patients' required undergo strict oral hygiene regimen and dental follow-up visits. The relatively larger appliance contributes to overall patient discomfort which expressed by esthetic and functional changes, such as phonetics and speech, mastication adaptation and chewing discomfort. The surgical method utilizing the zygomatic buttress by ZGA, involve surgical exposure of the zygomatic process and mini-plate head express into the oral cavity connected to the active distalizing device. The concept of
subsequent surgical exposure of the site and partially submerged object leaving a connection between sterile bone zones to the oral cavity, may potentially lead to a variety of infections and pathological conditions, as we discovered in our review, soft tissue and mini plate infections as the main clinical complication [6,25]. However, the ZGA offer smaller intraoral distalizing device which contribute to improved intraoral comfort during the distalization period.

PRACTICAL RECOMMANDATIONS

Our suggestion of clinical classification regarding safe anchorage load scale for monitored skeletal anchorage with minimal anchorage loss described in Table 7. The clinical guide for safe load of skeletal anchorage systems rely on the principle of subdividing load among skeletal anchorage devices amount in relation to involved target dentition, or by distalization type. The skeletally anchored device force load limitation, aimed to actively engage the target dentition while preserving correct and safe range of reciprocal forces distribution during buccal segment distalization is recommended. Non-surgical approach may involve two sites of skeletal anchorage devices - palatal anchorage or inter-radicular, which may be located in buccal aspect or palatal aspect. Utilization of mini-implants or mini-screws amount directly related to expression of indirect force generation the anchorage may withstand under controlled and safe distalization without anchorage loss. Surgical approach utilize direct anchorage facilitation located in zygomatic process and involve surgical application of skeletal anchorage complex involve 3 mini-screws with mini-plate attachment. Based on our findings, every skeletal anchorage device is subjected to specific amount of load, as increased the amount of skeletal anchorage devices, the overall force magnitude, which the anchorage may withstand, is increased. Non-surgical approach recommended load is limited to 300g of force generation, while surgical approach may facilitate higher force magnitude in order to facilitate greater distalization distance.
Table 7: Clinical classification of skeletal anchorage distalizers.

<table>
<thead>
<tr>
<th>Amount of skeletal anchorage devices</th>
<th>Anchorage load</th>
<th>Type of distalization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Non-surgical - palatal or inter-radicular skeletal anchorage</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>Less than 200 gr</td>
<td>One By One</td>
</tr>
<tr>
<td>2</td>
<td>200-250gr</td>
<td>En-Masse</td>
</tr>
<tr>
<td>3</td>
<td>250 to 300 gr</td>
<td>En Masse</td>
</tr>
<tr>
<td>Surgical - Zygomatic Skeletal Anchorage or Zygoma Gear Appliance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3 + mini plate</td>
<td>300 to 450gr</td>
<td>En-Masse unilateral or bilateral</td>
</tr>
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</table>
CONCLUSIONS

1. Based on our results, Zygoma Gear Appliance found to be more efficient skeletal anchored distalization method than Palatal Skeletal Anchorage system for maxillary buccal segment distalization.

2. Non-extractive therapy alternative suggestion by maxillary buccal segment distalization in greater space deficiency than 3 mm was approved.

3. According our comparative evaluation, distalization success rate and anchorage loss prevalence for Zygoma Gear Appliance, representing surgical direct anchorage distalization method, found to be more effective distalization system than Palatal Skeletal Anchorage.
REFERENCES


24. Sa’aed NL, Park CO, Bayome M, Park JH, Kim YJ, Kook YA. Skeletal and dental effects of


## ANNEX

### Annex 1. Search strategy

<table>
<thead>
<tr>
<th>Database</th>
<th>Keywords combination</th>
<th>Applied filter</th>
<th>Date</th>
<th>Result</th>
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<td>&quot;mini implant&quot; OR &quot;tad&quot; OR &quot;mini screw&quot; OR &quot;skeletal anchorage device&quot; OR &quot;zygomatic anchorage&quot; AND &quot;molar distalization&quot;</td>
<td>-</td>
<td>2018. 02.06</td>
<td>18</td>
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| SCIENCE DIRECT | "mini implant" OR "tad" OR "mini-screw" OR "skeletal anchorage device" OR "zygomatic anchorage" AND "molar distalization" | • Search refine : Journal, Books  
• Publication date: above 2007 | 2018. 02.05 | 176    |
| AJO-DO      | mini implant OR tad OR mini screw OR skeletal anchorage device OR zygomatic anchorage molar distalization  
• Results presented in "articles" tab | • "Title/Abs/Keywords"  
• Date: From January 2007 to December 2017 | 2018. 02.06 | 119    |
| SCOPUS      | {mini implant} OR {TAD} OR {mini screw} OR {skeletal anchorage device} OR {zygomatic anchorage} AND {molar distalization} | • "All field"                                      | 2018. 02.06 | 44     |