DEEP BITE CORRECTION USING TRUE OR RELATIVE INTRUSION. WHICH IS BETTER? A SYSTEMATIC REVIEW AND META-ANALYSIS

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Introduction: Deep bite is one of the challenges which orthodontists face. Treating this with true intrusion or relative intrusion is the question we would like to explore to find an answer in this review. The aim is to find out which intrusion method Is better in terms of incisors intrusion, molars extrusion overbite reduction, treatment duration, root resorption and stability.

Methods: 4 electronic databases were searched; Medline, Scopus, PubMed and Web of Science up to march/2019 (updated 11/2019) combined with a manual search among the reference lists of the included and relevant studies. Unpublished grey literature was searched using ClinicalTrials.gov. Randomized trials and prospective cohort studies were included. There were no restrictions on the search, and authors were to be contacted if necessary. Data were extracted using pre-standardized data extraction forms. Quality assessment was performed using the Cochrane's risk of bias tool for randomized and non-randomized studies respectively.

Results: 15 studies (2 randomized and 13 prospective cohort) met the inclusion criteria. Most were prospective studies with considerable potential for bias. 7 studies were included in the quantitative synthesis and 3 meta-analyses were undertaken for 3 different outcomes. Meta- analysis comparing intrusion of incisors found significant difference between the 2 groups (MD=0.63mm, 95%CI 0.37 to 0.88, P<0.0001). For molars extrusion significant difference was found between the 2 groups (MD= -0.27, 95%CI -0.45 to -0.08, P=0.005). No significant difference was found for both groups (MD=0.09mm, 95%CI -0.25 to 0.43).

Conclusion: There is evidence to support true intrusion of incisors with mini screws, but it is weak. Overbite reduction with either processes is equally effective, and the evidence is weak as well. Therefore, there is need for more high-quality studies in the future.

verbite is measured by how much the maxillary incisors overlap the mandibular incisors vertically [1]. Deep bite is an increase in this vertical

overlap. Deep bite is mostly associated with class II division 2 type malocclusions. A large cross-sectional study in the United States reported that 15% - 20% of the population had overbite >5mm [2].

Extremely deep may be associated with impingement of the palatal tissues, resulting in damage to the periodontium on the lingual surface of the maxillary incisors.

Different methods are used to treat deep-bite malocclusions. They range from removable appliances to fixed appliances. All these methods use the concept of either proclination of incisors, intrusion of incisors and extrusion of molars. Although all these treatments reduce deep bites, it is not clear which treatment is better than the other in terms of tooth movement (intrusion/extrusion), amount of overbite correction, time to treat, root resorption and stability.

Objectives

The aim of this systematic review was to identify the various intervention techniques of deep bite correction. The effectiveness of these different interventions. Whether *true intrusion* via temporary anchorage devices should be the treatment of choice or *relative intrusion* with the help of intrusion arches should be considered. Which of these gives better achievement of required objectives in the clinical practice?

MATERIALS AND METHODS

Protocol and registration

This systematic review was registered with the University of Dundee as a dissertation as part of the Master of Science degree in orthodontics (MSc).

Eligibility criteria

The following selection criteria were applied for the review.

1. Study design: randomized or quasi- randomized control trials and non- randomized prospective studies.
2. **P**articipants: Orthodontic patients with deep bite.
3. **I**ntervention: orthodontic deep bite correction.
4. **C**omparison: orthodontic deep correction using another method/appliance or untreated control.
5. **O**utcomes: tooth movement (intrusion / extrusion) measured on (casts, Ceph), amount of OB correction, time to treat, root resorption and stability.

Information sources, search strategy and study selection

We obtained article citations from March 16th,2019 to November 16th,2019 through an electronic search of the following electronic databases: PubMed, Scopus, Web of Science and Medline. In addition, on-going unpublished grey literature was searched for in ClinicalTrials.gov. Search strategies and keywords are listed in (Appendix).

No restrictions were added on language or publication date while searching databases. The screening of the search results for inclusion of relevant studies was performed by two reviewers (A.K.) and (A.M.) and disagreements were resolved by a third reviewer (A.H.). Quality assessment and data extraction was also done in combination. Full length articles were requested from theUniversity library for articles that were selected by initial screening. The reference list of retrieved articles was then manually searched. The complete text was obtained for any articles that were deemed to be potentially relevant.

Data extraction and collection

Data extraction was conducted separately by two authors (A.K.) and (A.M.) in duplicate using pre-standardized data extraction templates.

Study characteristics (study design, setting, methods, etc.) and sample characteristics (sample size, age, gender, type of interventions, etc.) were collected. Outcome measurements, results, conclusions and funding were also part of data extraction forms.

Risk of bias/ quality assessment in individual studies

The Cochrane's risk of bias tool was used to assess the risk of bias in all the studies [3], where seven

domains were assessed to be high, low or unclear risk. It was determined that if a study had high risk of bias in any of these sections other than "blinding of outcome assessment", the overall judgement of the study would be "high risk of bias". And if it had domains with unclear risk, then the study had unclear risk of bias. Studies with at least 6 domains being low risk were assessed to have low risk of bias.

Quality assessment was performed by two reviewers

Summary measures and approach to synthesis

Following quality assessment and data extraction, the main data and outcomes of all the included studies were to be summarized in a single summary table. Studies with similar comparisons, similar techniques used and reporting the same outcomes as asked in the review question were collected for quantitative synthesis (meta-analysis), using the software "RevMan ver. 5.3". For the outcomes that were not reported in more than two similar articles, due to different methods of reporting or parameters of measuring, we reported the reason and a narrative analysis was written. For continuous outcomes, the mean differences and standard deviations were calculated, while for dichotomous outcomes, the risk ratios were to be combined. The sample size was also inserted, since it affects the weight of the study.

Heterogeneity was assessed visually by noticing the amount of overlap between the confidence intervals, where poor overlapping indicates presence of heterogeneity. In order to quantify heterogeneity, I-square test would also be used with values below 30% indicating minimal heterogeneity and values above 50% indicating substantial heterogeneity. A random effects model was to be used in order to weigh the amount of heterogeneity present [4]. A fixed effects model was to be used only when minimal or no heterogeneity was suspected.

Additional analysis

If enough "low risk of bias" studies were found in the meta-analysis, it was planned to undertake a sensitivity test in order to assess the robustness of the results and judge the effect of each study on the result.

RESULTS

Study selection and results

The electronic search resulted in 813 results, while the manual search resulted in 3 results. The results of the search were added to the software "Zotero software" which removed the duplicates resulting in 470 results. The articles then had their titles and abstracts screened and assessed for eligibility. 447 studies were excluded resulting in only 23 remaining. After acquiring the full text for the 23 articles, 9 were excluded, where 1 study was in a different language, 2 were systematic reviews, 1 was retrospective, 1 study in-vitro 2 studies were clinical studies with no trials. The last two studies were a comparative study only. The remaining 14 studies 19,6,8,11,12,14,17,18,5,7,9,13,15,16 were included. 2 Studies were RCTs 19,6, 6 studies were quasi RCTs [8,11,12,14,17,18] and 1 more prospective study was added after researching the data bases again on November the 16th, 2019 [10]. The remaining seven were non-randomized prospective cohort studies [5,7,9,10,13,15,16]. A summary table for the data extraction was formed (Table 1). All the 15 studies were included in the qualitative synthesis, but only 8 were considered for the quantitative synthesis 7,10,12,13,14,15,16,17 as they were comparing similar methods and results. These studies were comparing mini screws against some sort of intrusion arches for *overbite reduction*, *incisors intrusion* and *molars extrusion*. One study [7] did not report results like the other seven studies had reported and it could not be included for meta-analysis. A PRISMA flow chart was generated to show the process of study identification (Fig.1).

Risk of bias within the studies

For randomized studies the Cochrane risk of bias tool was used. Overall, 8 studies [11,13,9,14,16,5,7,8] were assessed as having unclear risk of bias in general with a tendency towards being high risk. 2 studies were found to have low risk as their design satisfied the reviewers [19,6]. A summary graph is given

below which explains the risk of bias (Fig.2).

Results of individual studies, meta-analysis and additional analysis

Only 7 articles comparing mini screws against some sort of intrusion arches fulfilled all the criteria of selection and were used for meta- analysis. The quantitative synthesis was only possible for 3 outcomes; incisors intrusion, molars extrusion and overbite reduction. The "incisors intrusion" was measured in millimetres using lateral cephalograms to measure the difference between pre and post position of teeth. The data from 7 studies [19,12,13,14,15,16,17] was pooled together along with subgroups. We had to calculate the mean difference and standard deviation for some studies from the raw data provided. A Random effects meta-analysis showed significant difference between the 2 groups (MD=0.63mm, 95%CI 0.37 to 0.88, P<0.0001).

There was some heterogeneity found between the studies with I^2=37% and Chi^2=15.90 (**Figure 3**). Only 4 studies [10,12,14,17] could be collected for "molars extrusion". 2 studies [15,16], did not report the data in proper values. Initially it was intended to contact the authors, but with the help of a statistician and Cochrane handbook for systematic reviews of interventions these values were calculated, and the missing data was acquired. This was done to evaluate the study authors reporting error. A random effects meta-analysis was undertaken after combining the risk ratios, and it showed a difference between two groups (MD= - 0.27mm, 95%CI -0.45 to -0.08, P=0.005). There

was considerable heterogeneity between the studies with I^2 which was 81% and Chi^2 =26.76 (**Figure 4**). The third outcome "overbite reduction was found to be same for both groups. There was no statistically significant difference between the 2 types of intervention being investigate.

Figure 1: Prisma flow chart for identification of the studies.
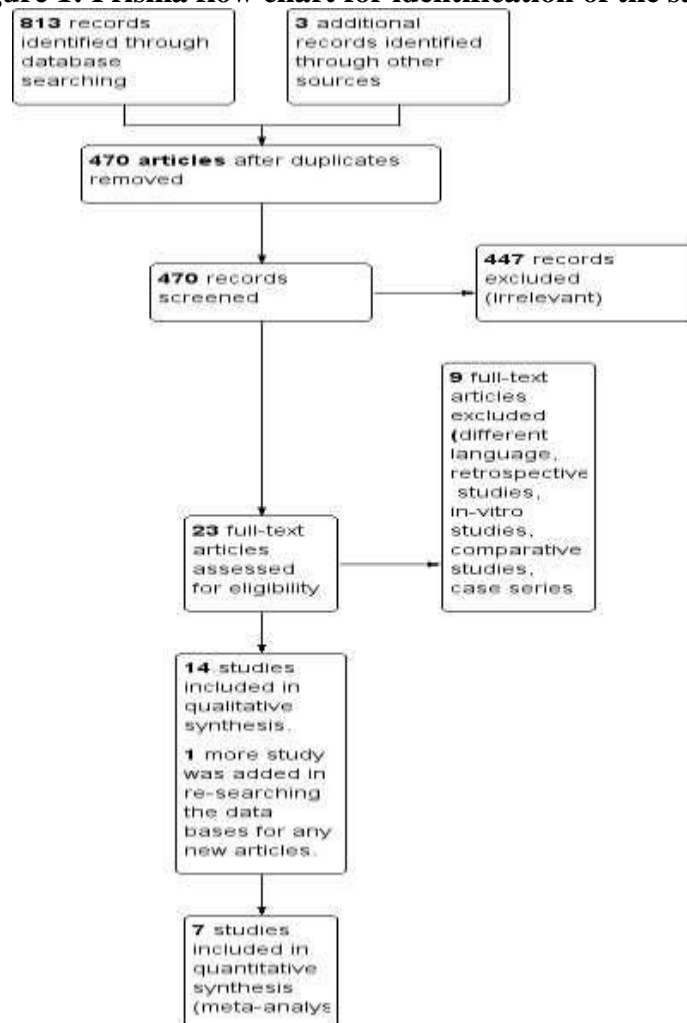
We were not able to pool the data for the remaining outcomes either because less than 2 studies reported the outcome, or because the reporting method and measuring parameters differed. "Duration of treatment" was evaluated properly in 2 studies [15,13] Other studies either did not measure or report them properly, they just mentioned in one statement that both groups took this much amount, of months for intrusion with no standard deviation mentioned. "Root resorption" was reported differently in 4 studies [6,8,9,11], these studies had different comparisons and so different materials and methods were applied for the intervention. That is why meta-analysis was not possible. 1 study was an RCT, 1 was quasi RCT and 2 were prospective studies. It was found that it is directly related to the amount of force application and how fast is the rate of intrusion. Although the root resorption occurs in every orthodontic treatment, but severe resorption occurs when an excessive force is applied.

Table 1: summary of included studies

Study	Study design	Ages (years)	Sample size	Intervention	Outcome measurements
Goel et al, 2014	Quasi RCT	14 – 25	30	Group I: Rickett's utility arch 0.017× 0.025 TMA Group II: K-SIR arch 0.017× 0.025 TMA	Incisors intrusion (SN-U1, PP-U1) Molar extrusion (PP-U6). Root resorption, Intrusion rate.
Jain et al, 2014		16-22	30	Group I: Mini implant anchorage. Group II: J-Hook Headgear Group III: Ricketts utility arch	Incisors intrusion (PP-U1) Molar extrusion (PP-U6)
Aras and Tuncer,2016	RCT	19±3.5	32 started 31 ended	Anterior mini implant group Posterior mini implant group	Root lengths and Root volumes
de Almeida et al 2018	Quasi RCT	G1: 13-17 G2: 16-28	50 started 28 ended	-Group I: CIA mechanics -Group II: Mx levelling and alignment Md: reverse curve of Spee	Intrusion for -Mx Rt.1, Mx Lt1, -Mx Rt.2, Mx Lt.2.
Aydogdu and Ozsoyb 2011	PCCT	14 -18	26	TADs Group: Between mn 2s and 3s. Conventional utility arch Group: mandibular utility arch	Mandibular incisors intrusion (HRP -Mand1 (tip), HRP-Mand1 (cr)) and (Xi-Pm/Mand1 (cr), Xi- Pm/Mand1 (tip)) Molar extrusion (Xi-Pm/Mand6mm)
Kumar et al 2015	Quasi RCT	15 -20	30	--Skeletal anchorage devices G 1 --Connecticut intrusion arch G 2	--Centroid point to PP (incisor intrusion) --U6 to PP (molar extrusion)
Senışık and Türkkahram an 2011		> 16	45	--Group I: CIA --Group II: Implant group --Group III: control group	Incisors intrusion, (U1 (cr), tip), molars extrusion (U6 (cr) and tip, Overbite.

Amasyali et al, 2005	PCCT	14 – 15.5	20	CIA UIA	Overbite, U1-PP, U6-PP, ANS -Me
Raj et al, 2015		14 -20	20	Burstone intrusive arch Mini implants	U1-PP, overbite Cr-PP, overjet.
Polat-Özsoy et al, 2011		G1: 12-28 G2: 11-19	24	TADs Group: distal to maxillary 1s. Utility arch Group:	U1-PP, Cr-PP, overbite, overjet.
Kaushik A, et al 2016	PCCT	14 – 25	38	Group 1: UIA Group 2: CIA Group 3: Mini screw	incisor intrusion - U1-PP, U1-SN, U1Cr-PP, L1- MP. molar extrusion
McIntyre GT 2019, In progress"	RCT	9 – 16	35 started 13 ended	- Group I: Fixed anterior bite planes Group II: control	Occlusal reestablishment, Ui-Mx plane angle, LI-Mn plane angle, Photographs, Questionnaire
Deguchi et al 2008	PCCT	G 1: 18-24 G 2: 18-25	18	Group 1; J-Hook HG intrusion. Group 2; Implant group	UL – U1, PP – U6, PP – U1, Overbite, Overjet
Van Steenbergen et al., 2004	Quasi RCT	9 – 14	20	Head gear group Intrusion arch group	Incisors intrusion Molar extrusion
El Namrawy et al., 2019	PCCT	17-29	30	Group 1: mini screws Group 2: intrusion arch	Incisors intrusion (U1-PP, Cr-PP) Molars extrusion (U6-PP, Cr-PP) Overjet, Overbite

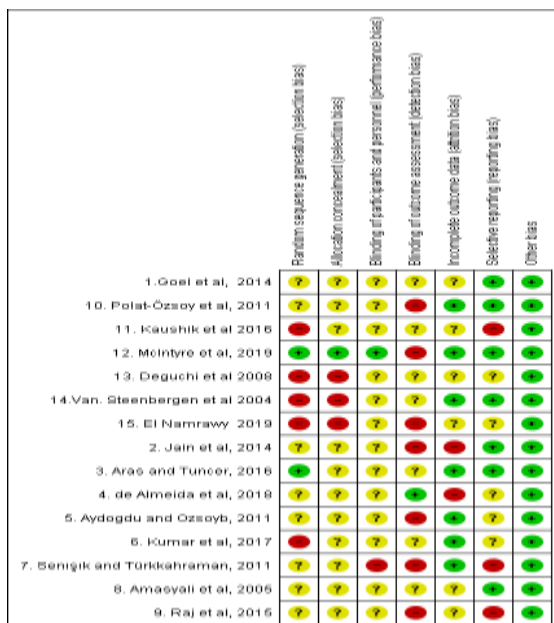"Stability" was not reported in the selected studies.

Figure 2; Risk of bias summary for each of the included studies

DISCUSSION

A meta-analysis is a statistical approach to combine the results from separate but similar studies to provide an overall summary of the effect of interest. Caution is advised with the results of meta-analysis, because one can see from the figure of risk of bias (**figure 2**), how much bias is present between the studies.

Out of the 15 included studies, 7 were eligible for carrying out the quantitative synthesis and it was possible to pool the data for 3 different outcomes and undertake 3 meta-analyses. One meta-analysis showed that both techniques had similar results, "overbite reduction" with no significant difference. Meta-analysis on "incisors intrusion" found significant difference between the 2 groups. The third meta-analysis found that "molars extrusion" was slightly more with intrusion arches compared to mini screws which, exhibited lesser extrusion. This difference was found to be statistically significant. Random effects models were used for these three outcomes and then an additional sensitivity test was performed to see the level of heterogeneity between studies. It was noticed that for "incisors intrusion" the heterogeneity between the studies reduced when the subgroup of one study [17] was removed. For the remaining outcomes; "root resorption", "time to treat" and stability, it wasn't possible to undertake meta-analyses because of lack of at least 2 studies measuring and reporting the same outcome in the same manner. Although the root resorption could not be meta- analyzed, but it was evident that root resorption occurs almost at same level of significance between both comparison groups, with some method causing resorption slightly more than the other. The evidence is weak because the study design is non-randomized.
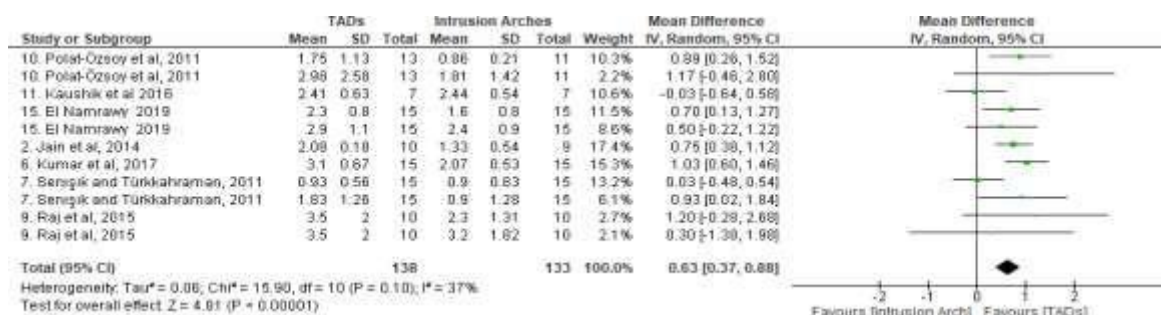

Figure 3: Forest plot for *incisors intrusion*. Comparison between TADs vs Intrusion arches
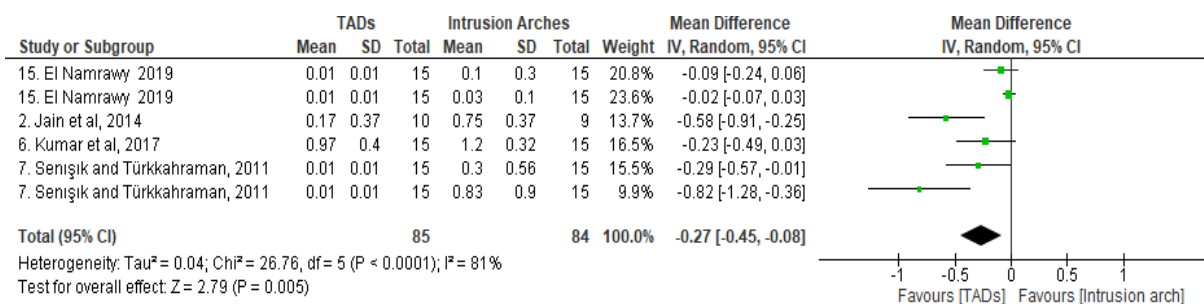

Figure 4: Forest plot for *molars extrusion*. Comparison between TADs vs Intrusion arches

"Overbite reduction" was found to be same for both the comparison groups. A meta-analysis was done for six studies and it was found that they all overlap the zero effect and no statistically significant difference was found for overbite reduction. If the overbite reduction is same for both methods, then we see that there are other features involved in overbite reduction for intrusion arches. These features are; incisors proclination and somewhat molars extrusion. The clinicians needs to be vigilant in treatment planning whether the incisors proclination is acceptable for the case or not.

Limitations

There were no limitations on the language or date of publication during conducting the electronic search. But the systematic review had language bias, as literature not in English was excluded from meta-analysis and qualitative analysis. There was heterogeneity in population amongst the studies, as

some authors included patients with 2 mm overbite, and some had pupil with more than 5 mm overbite. In one study (Polat) group1 is having a bigger age range than the comparative group. "Stability" wasn't measured as an outcome in any of the studies.

Meta-analysis for *root resorption* was not possible as the reviewers could not gather studies reporting the same outcome in the same manner let alone using similar interventions.

Many of the studies have been presented as RCTs, however on analysing them it appeared that the study design was a prospective or a case-controlled trial. This increased the bias of study grading the quality of paper as low quality evidence.

CONCLUSION

The quality of the evidence is weak, but it suggests that there was statistically significant difference between the mini screws compared to intrusion arches in terms of two outcomes; "*incisors intrusion*" and *"molars extrusion"*. TADs give more incisors intrusion than intrusion arches.

Molar extrusion occurs more in the intrusion arches group.

True and relative intrusion are equally effective in terms of deep overbite reduction. True intrusion occurs with mini screws, but it was also noticed in some studies that the incisors proclination do occurs with TADs. The incisors proclination is a common phenomenon found in intrusion arches.

Recommendations for future studies (RCTs)

There is a need for more high quality RCTs.

A well designed RCT would produce a high- quality study. This would facilitate undertaking a meta-analysis of some significant results.

Recommendations for clinical practice

Although there are limitations for quality of evidence, which is quite weak, it is suggested that no technique is superior to the other, and the difference between the 2 techniques is insignificant, in terms of *overbite reduction*.

TADs are useful for high angle patients and with excessive gummy smile, where extrusion of molars is not acceptable. It is up to the clinician to assess the need of the hour, whether to accept proclination or molar extrusion. It depends on case requirement.

ACKNOWLEDGEMENT

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APPENDIX

PubMed	((orthodontic* OR malocclusion/therapy OR comparison) AND ("deep bite" OR "deep overbite") AND ("incisors intrusion" OR "true intrusion" OR extrusion OR "incisor/pathology*" OR appliance*) AND ("tooth movement" OR biomechanics OR "time factors" OR "root resorption" OR correction OR stability))	
		resorption" OR correction OR stability))

	Web of science	((orthodontic* OR malocclusion/therapy OR comparison) AND ("deep bite" OR "deep overbite") AND ("incisors intrusion" OR "true intrusion" OR extrusion OR "incisor/pathology*" OR appliance*) AND ("tooth movement" OR biomechanics OR "time factors" OR "root resorption" OR correction OR stability))
	Clinical trials.gov	Deep bite
	Additional article	Evaluation of apical root resorption in orthodontic patients with maxillary anterior intrusion using utility arches and mini screws: a comparative clinical trial.
Medline	((orthodontic* OR malocclusion/therapy OR comparison) AND ("deep bite" OR "deep overbite") AND ("incisors intrusion" OR "true intrusion" OR extrusion OR "incisor/pathology*" OR appliance*) AND ("tooth movement" OR biomechanics OR "time factors" OR "root resorption" OR correction OR stability))		
Scopus	("orthodontic" * OR "malocclusion" OR "comparison" AND "deep bite" OR "deep overbite" AND "incisor intrusion" OR "true intrusion" OR "extrusion" OR "incisor/pathology*" AND "biomechanics" OR "time factors" OR "root resorption" OR "correction" OR "stability"). **Combined with** OR ((orthodontic* OR malocclusion/therapy OR comparison) AND ("deep bite" OR "deep overbite") AND ("incisors intrusion" OR "true intrusion" OR extrusion OR "incisor/pathology*" OR appliance*) AND ("tooth movement" OR biomechanics OR "time factors" OR "root		