DOI: 10.7860/JCDR/2024/67817.19443

Original Article

Dentistry Section

Comparative Analysis of Canine Distalisation between Ceramic and Metal Brackets: A Systematic Review

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ABSTRACT

Introduction: Orthodontic treatment frequently entails the distalisation of canines to address various malocclusions, involving moving the canines towards the posterior region of the dental arch. A crucial consideration in this treatment is the type of bracket material utilised, as it can impact the efficacy and efficiency of Canine Distalisation (CD).

Aim: To analyse various in-vivo studies to evaluate the comparison of the rate of maxillary CD between Ceramic Brackets (CB) and Metal Brackets (MB) during fixed orthodontic treatment. Secondary factors assessed include the loss of anchorage, canine rotation, and canine tipping.

Materials and Methods: Articles were searched in electronic databases such as Google Scholar, Scopus, and PubMed. The search strategy was designed by two authors, AK and RKJ. The search did not include date restrictions. The list of references for the included articles was also searched. The systematic review included two Controlled Clinical Trials (CCT) and one Randomised Control Trial (RCT). Two authors, AK and RKJ, independently screened the titles, abstracts, and full texts of the identified studies during the literature search and then combined their findings. The information considered from the short-listed studies included the first author, year of publication, rate of CD, CB, and MB. Cochrane's Risk of Bias (RoB) tool, RoB2 tool, and the Newcastle Ottawa scale were used to analyse bias.

Results: The present review incorporated three studies. The analysis of the RoB indicated low RoB in one study and fair RoB in the other two. The systematic review highlighted that there was no significant difference in the rate of CD between CB and MB.

Conclusion: The available evidence was limited and of moderate quality, showing no difference in the rate of CD performed using ceramic and MB. Hence, clinically, there is no difference in using metal or CB, even though CBs are known to have higher SR in in-vitro evaluations.

Keywords: Orthodontic brackets, Orthodontic space closure, Tooth movement

INTRODUCTION

First premolar extraction is one of the treatment plans for alleviating moderate to severe crowding or proclination of the teeth [1]. Space closure by Canine Distalisation (CD) is a routine orthodontic procedure that requires an effective technique. The mechanics to achieve CD include non frictional and frictional mechanics, which typically take an average of 6 to 9 months [2]. A rapid and accurate tooth movement, involving bodily tooth movement without rotation, is most desired in canine retraction [1]. One of the common concerns of patients undergoing orthodontic treatment is the time taken for its completion.

Metal Brackets (MBs) are known to have lower frictional resistance but inferior aesthetics, leading to the introduction of CBs. While CBs are aesthetically pleasing, previous studies have shown that CBs have higher frictional resistance compared to MBs [3]. Friction, an undesirable property, can slow down tooth movement [4]. CBs with metal slots were introduced to combine the low frictional property of MBs with the aesthetic appeal of CBs [5]. Self-ligating Brackets (SLB) are recommended for their low frictional resistance, reduced treatment time, enhanced clinical efficacy, improved patient compliance, fewer appointments, and better plaque control [6].

Previous in-vitro studies examined the loss of force due to friction between Monocrystalline (MCA), Polycrystalline (PCA) CBs, and MBs. MBs and PCA brackets showed no significant difference in CD, while MCA and PCA brackets, as well as MCA brackets and CBs, exhibited a significant difference [7]. An in-vitro study evaluated the frictional force between CBs, metal-lined CBs, and MBs using various bracket-archwire combinations, revealing that metal-lined CBs produced significantly less frictional force compared to conventional CBs, albeit greater than that of MBs [8]. Another in-vitro study assessed friction between CBs and MBs during simulated CD, showing that CBs produced significantly less tooth movement compared to MBs [9,10]. Since CBs are commonly used and there are no systematic reviews comparing them with MBs for CD, the present review was planned and executed. Thus, the present review aimed to systematically analyse the available literature on the difference in the rate of CD, anchorage loss, canine rotation, tipping of canines, and changes in transverse arch dimensions.

MATERIALS AND METHODS

Protocol and registration: The systematic review followed the guidelines outlined in the Preferred Reporting Items for Systemic Reviews and Meta Analyses (PRISMA) 2020 statement. The systematic review protocol was registered in the PROSPERO database.

Search strategy: A systematic search of medical literature published up to July 2023 was conducted to identify all articles relevant to the research question. PubMed, Google Scholar, and Scopus were the electronic databases searched. Two authors (A.K. and R.K.J) conducted the search for articles to be included in the systematic review. Other databases were also searched using similar keywords, and only English literature was included. Duplicates were removed using Rayyan software. The references of the included articles were manually searched for other relevant articles.

PICO analysis:

Population: Patients in need of fixed orthodontic treatment

Intervention: CB

Comparison: Conventional brackets

Primary outcome: Rate of canine retraction

Secondary outcomes: Anchorage loss, canine rotation, tipping of canine, and changes in transverse arch dimensions.

Study design: Randomised controlled trial or CCT.

Selection of Studies:

Inclusion criteria:

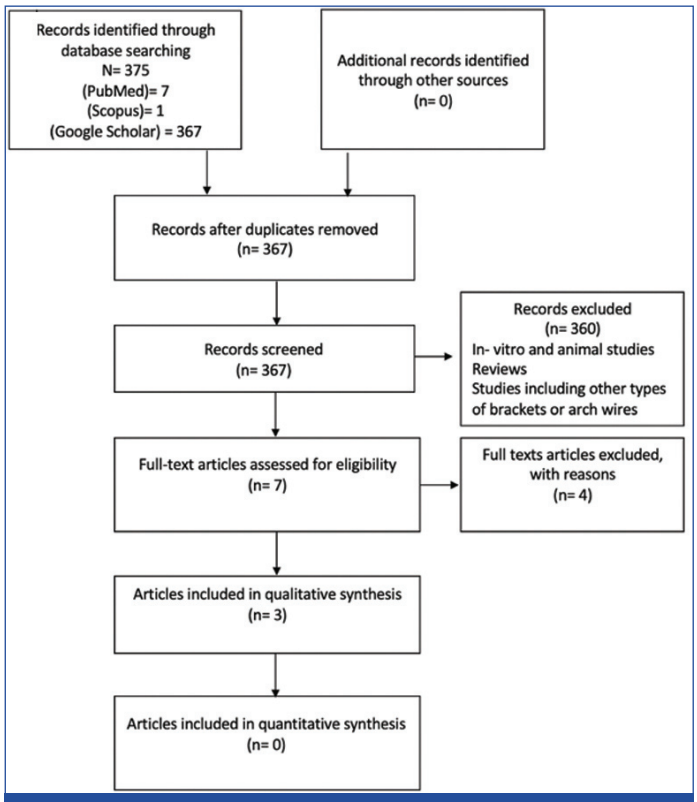
- Human clinical trials of class I and II malocclusion subjects with crowding or proclined maxillary incisors, having a full set of healthy non carious permanent teeth, requiring fixed orthodontic appliance therapy with extraction of first premolar teeth.
- Split-mouth trials comparing CBs and MBs for CD.

Exclusion criteria:

- Studies without a comparison group.
- Studies using Temporary Anchorage Devices (TADs) or loops for space closure.
- In-vitro studies.
- Animal studies.
- Letters to the editor, review articles, case reports/series, and studies published in languages other than English.

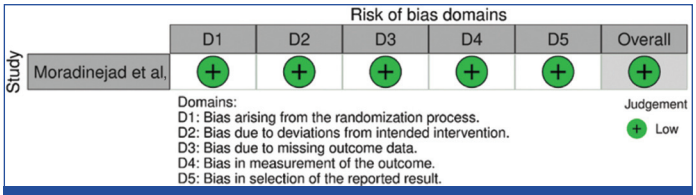
Study Procedure

Only studies that met the inclusion criteria were included in the present review. [Table/Fig-1] depicts the process of study selection for the review. The study selection process, bias assessment, and tabulation were conducted by two authors (AK and RKJ). Any lack of agreement was resolved through discussion. Data from the included studies were retrieved by both authors (AK and RKJ).



[Table/Fig-1]: PRISMA flowchart.

Qualitative assessment: The qualitative assessment of the randomised clinical trials was performed using the Cochrane RoB2 tool, as shown in [Table/Fig-2] [11]. For the CCTs, the assessment was done using the Newcastle-Ottawa Scale (NOS), as depicted in [Table/Fig-3] [12,13]. Five criteria were used to assess the studies: 1) description of the method of randomisation; 2) performance of intention-to-treat analysis; 3) statement on blind assessment; 4) reporting of allocation concealment; and 5) conducting a power calculation for sample size.



[Table/Fig-2]: Cochrane Risk of Bias (RoB) tool-RoB2 tool for quality assessment of RCTs [11].

Question	John JR et al.,	Shaik JA and Guram G,
A. **Selection** 1. Is the case definition adequate?	*	*
2. Representativeness of the exposed cohort	*	*
3. Selection of the controls	-	-
4. Definition of controls	-	-
B. **Comparability** 1. Comparability of the cases and controls based-on the design or analysis a. Rate of CD b. Anchorage loss	*	**
C. **Exposure**		
1. Ascertainment of exposure	-	-
2.The same method of ascertainment for cases and controls	*	*
3. Non response rate	*	*
Number of stars in this domain	5	6
Quality	Fair	Fair

[Table/Fig-3]: Newcastle-Ottawa Scale (NOS) for quality assessment of the CCTs [12,13].

The quality of the CCTs included in the trial was determined by the NOS, which uses a 'star system' to evaluate the included CCTs, as shown in [Table/Fig-3]. The assessment is divided into three headings: 1) Selection of groups with four subdivisions; 2) Comparability of groups with one subdivision; and 3) Exposure assessment with three subdivisions. Each item in the study can receive a maximum of one star in the selection and outcome categories, with a maximum of two stars for comparability.

1) A study can be categorised as good quality if the total number of stars is 7 to 8.
2) It is categorised as fair quality if the total number of stars is 5 to 6.
3) It is categorised as poor quality if the total number of stars is less than 5.

RESULTS

Study selection: A total of 375 articles were identified in the electronic search. After using the Rayyan software to remove duplicates, 367 studies were screened. Subsequently, seven studies were selected based on the eligibility criteria after screening the titles. Four studies were excluded from further screening due to not meeting the eligibility criteria. Three studies were excluded, one being an in-vitro study, one a systematic review, and one assessing biofilm formation, which was not relevant to the present systematic review. Finally, the qualitative analysis of three relevant studies was conducted, with one being an RCT and two being CCTs.

Study characteristics: A summary of the characteristics of the three included studies is provided in [Table/Fig-4]. One study evaluated the rate of CD, rotation, tipping, transverse arch dimensions, and premolar mesialisation between conventional CBs and active self-ligating CBs [11]. The study spanned three months, and the changes were measured on superimposed three-dimensional digitised models [11] The second study assessed the rate of CD and loss of anchorage between conventional CBs and metal-lined CBs with MB [12]. The duration of the study was determined by the endpoint of CD, calculated as a point equidistant from the latest interval. The measurement of the

extraction space distances was conducted to evaluate the rate of CD, and anchorage loss was calculated using lateral cephalometric radiographs. The third study examined the rate of space closure between CBs and MBs. A digital calliper was utilised to measure the distance to the nearest 0.01 mm between the distal of the first molar buccal tube and the mesial of the canine bracket. Measurements were taken before distalisation began and after its completion on each quadrant. Three measurements were obtained each time, and in case of discrepancies, the mean average was calculated from the two closest measurements. The wire distal to the molar tubes was trimmed during patient recalls every five weeks. The spaces were measured, and the springs were evaluated for activation between 6 to 9 mm until distalisation was completed on one quadrant.

All the included studies evaluated the rate of CD as the primary outcome; other outcomes assessed were canine rotation, loss of anchorage, changes in transverse arch dimensions, and tipping of canines.

Risk of Bias (RoB) of the included studies: Among the three studies included, two reported a moderate RoB, and one reported a low RoB as sample size calculation, sample randomisation, and blinding of data were mentioned.

Rate of CD: Two studies reported no difference in CD rate between CB and MBs, and one study reported a significant difference in CD between ceramic SLB compared to conventional CBs. Moradinejad M et al., concluded that CD with conventional CBs was two times faster than the ceramic self-ligating group and was statistically significant (p=0.001) [11]. John JR et al., reported that the rate of CD between CBs and MBs showed no significant difference [13]. Shaik JA and Guram G reported that CBs with a metal slot reduced frictional resistance compared to conventional CBs, but the difference was not clinically significant when compared to MBs (between MBs and metal-lined CBs p=0.26 and between CBs and MBs p=0.07) [12]. The characteristic table of the included studies has been depicted in [Table/Fig-4][11-13].

Loss of anchorage: Two studies reported loss of anchorage. Moradinejad M et al., noted a similar mean anchorage loss between CBs and metal-lined CB groups (p=0.796). Shaik JA and Guram G reported no significant difference in the anchorage loss of teeth bonded with CBs with metal slots (p=0.68), CBs (p=1.0), and Preadjusted Edgewise Appliance (PEA) MBs [11,12].

Canine rotation, tipping of canines, and changes in transverse arch dimensions: One study reported canine rotation, tipping of canines, and changes in transverse arch dimensions. Moradinejad M et al., assessed canine rotation, tipping of canines, and changes in transverse arch dimensions in both groups [11]. CBs showed more than double the amount of rotation of the canine compared to the SLB group (p=0.001). Tipping of the canine was double in the CB group compared to the SLB group (p=0.002). Expansion of the arch was greater in CB than in the SLB (p=0.003). Both CBs and SLBs showed a similar amount of arch constriction at the premolar region (p=0.605). Expansion of the arch in the canine region was noted in both groups, though the expansion in the SLB group was lesser. In the canine area, they expanded the arch, with the SLB causing smaller extents of expansion.

DISCUSSION

To authors understanding, the present review on CD between CB and MB was the first ever to be performed. As adults are more concerned about aesthetics during fixed orthodontic treatment, a combination of aesthetics and good properties for orthodontic tooth movements is required. Hence, CBs have gained good popularity and have become an important part of clinical work. Although CBs are known to have superior colour stability, they have known disadvantages like bracket breakage and higher frictional resistance when compared to MBs [14]. The present review aimed to systematically analyse the present literature on the rate of CD. The current systematic review included the collated data from in-vivo studies that reported on the rate of CD. A total of three studies were evaluated for qualitative analysis to assess the following parameters: CD, loss of anchorage, canine rotation, tipping, and arch expansion. The studies were assessed for RoB using the RoB2 tool for RCTs and the Newcastle Ottawa scale for CCTs. It was concluded that the rate of CD and anchorage loss between CB and MB showed no significant difference with a moderate RoB. The RoB using the Newcastle Ottawa scale was adapted from the study by Arvind

Authors, year, Study design	Sample size and groups	Outcome measures and methods	Outcome assessed	Results	Inference
Moradinejad M et al., 2021 Single-blind split-mouth RCT [11]	16 subjects (13 F and 3 M) Mean age of 22.8 ± 5.9 years (range: 15-35) Group-1: Active ceramic SLB with a 22" metal slot and ceramic clip (Reference group) Group-2: Metal-lined CB	CD (mm), AL (mm), CR (°), CT (°) and changes in transverse arch dimensions (mm) CR using a 9 mm NiTi closed coil spring	CR and AL assessed on superimposed 3D models	CD with MCB was twice faster than that with SLB group (p=0.001) AL similar in both groups (p=0.796) CR in MCB was more than twice that in SLB (p=0.001) CT in the SLB group was about half of that in MCB (p=0.002) Arch expansion with MCB was greater than SLB group (p=0.003) Arch constrictions at the premolar sites were similar for both groups (p=0.605)	Duration of CD with SLB was higher but the amount of CR and CT was lower, AL was similar in both groups. Treated subjects had a similar arch constriction at the premolar and canine area in both groups, arch expansion with the SLB was lesser in molar region.
John JR et al., 2021 CCT [13]	18 subjects 18-25 years Group-1: CB 9 subjects (5 M and 4 F) Group-2: MBT Brackets 9 subjects (5 M and 4 F) (Reference group)	CD (mm) CD using a 9 mm NiTi medium Sentalloy coil spring	CR assessed with digital calliper	NS in CD between the two groups at the beginning of the investigation (p=0.632) NS in CD at the end of the treatment (p=0.049) CR in both groups were NS (p=0.692)	CR was almost similar in both the groups.
Shaik JA and Guram G, 2018 CCT [12]	12 subjects Group-1: 6 subjects received CB on one canine and PEA Metal Brackets (MB) on the other canine (Reference group) Group-2: 6 subjects received MCB PEA Metal Brackets (MB) on one canine and PEA Metal Brackets (MB) on the other canine (Reference group)	CD (mm) and AL (mm) CD using elastic chain	CR and AL assessed with a lateral cephalogram	NS in CD between MCB and PEA Metal Bracket (MB) groups (p=0.26) NS in AL between MCB and PEA Metal Bracket (MB) groups (p=0.68) NS in CD between CB and PEA Metal Bracket (MB) groups (p=0.07) NS in AL between CB and PEA Metal Bracket (MB) groups (p=1.0)	MCB generate lower frictional forces than CB but higher than PEA Metal Brackets (MB).

[Table/Fig-4]: Characteristic table [11-13].
CD: Canine distalisation; CR: Canine rotation; AL: Anchorage loss; CT: Canine tipping; CB: Ceramic brackets; MCB: Metal-lined ceramic brackets; SLB: Self-ligating brackets; PEA: Preadjusted edgewise appliance; M: Males, F: Females

P and Jain RK [15]. According to the scoring criteria, one study showed a low RoB while two studies showed a moderate RoB. Two studies did not mention the selection of controls, definition of controls, ascertainment of cases and controls, resolution of funding bias, and conflict bias. The randomisation method, variations from intended interventions, missing outcome data, assessment of outcomes, and choice of reported outcomes were all mentioned in one low-risk study.

No previous systematic reviews have been done comparing the rate of CD) between CB and MBT. In present review, the available literature on CD rates between the two brackets has been assessed. It can be assumed that the rate of canine retraction is higher with MBs as there is less friction in them compared to CBs. However, after systematically assessing the literature with moderate quality evidence, it can be inferred that the rate of canine distal movement is not different between the two types of brackets. The strength of the present review is the inclusion of only clinical studies RCT and CCT. Clinical studies are in the highest levels of evidence, hence conclusions derived are more valid in practice, and a systematic review of these studies can be considered as valid evidence. Frictional resistance in in-vitro studies has shown a significant difference, but most in-vivo studies do not show a significant difference in the CD rate between CBs and MBs [1].

A systematic review by Zhou Q et al., assessed the rate of CD and loss of anchorage between SLB and MB. It was concluded that SLB and MB showed the same rate of CD and anchorage loss [16]. A previous in-vitro study by AlSubaie M et al., evaluated the force loss due to friction and reported that MB (67±4%) showed the least amount of friction, followed by Polycarbonate (PCA) (68±7%) and Metal Composite Adhesive (MCA) CB groups (76±3%). No significant difference was noted between MB and PCA brackets (p=0.97), but significant differences were observed between MB and MCA brackets (p=0.03) and between PCA and MCA CBs (p=0.04) [7]. Cacciafesta V et al., performed an in-vitro study evaluating the friction of CB and metal-lined CB in different bracket-archwire combinations. The frictional force produced by metal-lined CB was lesser than that of the CBs but greater than that of MBs [8]. The study conducted by Shaik JA and Guram G concluded similar results [12]. Sukh R et al., conducted an in-vitro study on typodont models by simulating CD and evaluating the frictional resistance. It was compared between MBs, CBs, and metal-lined CBs, all with a 0.022-inch slot and seven Nickel Titanium (NiTi) and Stainless Steel (SS) archwires. It was noted that CB with NiTi archwires and elastomeric module ligation showed the greatest frictional resistance, whereas MB with SS archwires and SS ligature wire ligation showed the least amount of frictional resistance. MBs generated the least amount of frictional force followed by metal-lined CBs and the greatest by CBs [17]. The present systematic review included studies that used elastomeric chains and NiTi coil springs for CD [1]. A study performed an in-vivo study assessing the rate of CD with two different techniques. Elastomeric chains were employed from the bracket on one side and the power arm on the other to provide a force of distalisation while using TADs as anchorage units.

An in-vitro study on the frictional resistance of PCA and MCA CB compared to MB with two different archwires has shown that PCA CB exhibited significantly higher frictional force compared to MCA CB and MB, and rectangular archwires generated higher forces than round archwires [18]. Another in-vitro study evaluating the frictional resistance between CB, metal-lined CB, and MB combined with beta-titanium, NiTi, and SS archwires showed significantly higher frictional resistance in CB, followed by metal-lined CB and MB. Beta-titanium archwires exhibited the greatest frictional resistance, followed by NiTi and SS archwires [19]. Previous studies have reported that the rate of CD is highest with pre-adjusted brackets, followed by metal-lined CB, and least with CBs. CBs are an aesthetic alternative to MBs. Lower frictional resistance is generated with CB with the metal slot, which is an aesthetic option compared to CBs. Due to its shortcomings, the systematic review should be interpreted carefully [2,3].

Limitation(s)

The included studies in the systematic review showed methodological inconsistencies. One of the studies lasted for three months, whereas CD typically requires a duration of six to nine months. The results of these studies should be interpreted cautiously as different evaluation methods were employed to assess the same parameter, leading to increased study heterogeneity. Insufficient data were available to evaluate the CD rate and anchorage loss, canine tipping, and rotation. The use of different sizes of archwires for CD could potentially impact the rate of CD.

CONCLUSION(S)

The available moderate-quality evidence suggests that there is no difference in the rate of canine distal movement between conventional ceramic and MBs. The frictional forces during CD with metal-lined CBs were lower than with CBs but greater than with MBs.

Authors contribution: Conceptualisation, AK, RKJ; Methodology, AK, RKJ; Software, AK; Validation, AK, RKJ; Formal Analysis, AK; Investigation, AK, RKJ; Resources, AK; Data Curation, AK, RKJ; Writing- Original Draft Preparation, AK; Writing- Review and Editing, AK, RKJ; Visualisation, AK, RKJ; Supervision, RKJ; Project Administration, RKJ.

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PLAGIARISM CHECKING METHODS: [Jain H et al.]
- Plagiarism X-checker: Oct 03, 2023
- Manual Googling: Mar 22, 2024
- iThenticate Software: Mar 25, 2024 (8%)

ETYMOLOGY: Author Origin

EMENDATIONS: 7

AUTHOR DECLARATION:
- Financial or Other Competing Interests: None
- Was Ethics Committee Approval obtained for this study? NA
- Was informed consent obtained from the subjects involved in the study? NA
- For any images presented appropriate consent has been obtained from the subjects. NA

Date of Submission: **Oct 02, 2023**
Date of Peer Review: **Dec 27, 2023**
Date of Acceptance: **Mar 27, 2024**
Date of Publishing: **May 01, 2024**