Choosing the denture occlusion - A Systematic review

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Abstract

Aim: The aim of the study is to acquire evidence for the choice of occlusion with anatomic/modified anatomic teeth in complete denture prosthesis.

Settings and Design: Systematic review following PRISMA guidelines.

Materials and Methods: The study reviewed original articles on various occlusal schemes bilateral balance occlusion (BBO), lingual occlusion (LO), Canine guided occlusion (CG), posterior group function occlusion (PGFO) have been applied to the complete dentures and were analyzed for the objective or subjective or both evaluations. The data were collected in standard format with the needed information such as year of publication, type of study, occlusal schemes compared, test methodology used, sample size for experiment and control, assessment of retention, stability, and other factors which determine the quality of life and period of follow-up. The risk of bias was calculated using tools RoB2.0 and robvis. At all stages, the inclusion and exclusion of studies were discussed among the reviewers.

Statistical Analysis used: Due to the heterogeneity in the data of the included studies no statistical analysis was used.

Results: Of the 1896 articles screened only 17 studies were included in the systematic review. These were discussed amongst the reviewers regarding the various occlusion schemes used. The subjective and objective criteria used in the studies was tabulated separately. They were then analyzed for the risk of bias using the robvis 2 tool.

Conclusion: No scheme is more superior to the other with the anatomic tooth forms. The use of alternative unbalanced schemes produces a similar satisfactory clinical outcome. The ridge classification also has a significant role to play in the preference for an occlusal scheme.

Keywords: Balanced occlusion, canine-guided occlusion, lingualized occlusion, occlusal scheme, occlusion in a complete denture

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INTRODUCTION

The complete denture prosthesis is irreplaceable in the rehabilitation of edentulous patients. It restores oral function and maintains esthetics and patients' psychological well-being. With better medical services and a greater life span, there is an equal requirement of functional oral rehabilitation, where complete denture prosthesis too has an important role to play. This applies greatly to our developing country where implant-supported prosthesis is still away from the reach of masses. Their fabrication includes the right blend of art and science of stabilizing it against all odds of oral musculature, function, parafunction, and gravity. The basic principles to be born in mind while fabricating a complete denture include retention, support, stability, and harmony with stomatognathic system with preservation of the surrounding tissues to achieve good esthetics and function. Undesirable denture movement may result during function by unfavorable masticatory forces, but these can be minimized by multiple contacts on both working and nonworking sides during centric and all excursive mandibular movements.[1] Balanced articulation means the simultaneous anterior and posterior occlusal contact of teeth in centric and eccentric positions.[2] This concept has been applied clinically as it is assumed to dissipate the oblique forces and improve retention and stability.

However, alternatively, another approach called lingualized occlusion (LO)[2-4] has been advocated, where only the maxillary palatal cusps articulate with the mandibular occlusal surfaces.[5,6] There were reports of good acceptance of the latter too in terms of patient comfort. This makes us question the significance of the complicated procedures or rather time-consuming adjustments involved the balanced occlusion when speaking of clinical evidence. Moreover, here began a journey of various studies of different occlusal schemes and tooth forms.[5,6]

Various occlusal schemes other than the bilateral balanced occlusion and lingialized occlusion have also been used in denture fabrication. Schemes like Linear (Monoplane occlusion), Canine-guided occlusion, Partial group function occlusion, Buccalized occlusion have been researched upon.[6-15] The earliest mention of CGO in complete denture prosthesis was made by Gausch in 1986, where EMG (electromyographic) studies were done to explore the benefits. However, there is a need of more scientific evidence to apply these schemes in appropriate situations.[16]

Complete denture occlusion and its prospective effects on the stomatognathic system along with the quality of life of the patient hence is an area of interest. More evidence-based research is needed due to different biomechanics of conventional denture prosthesis and the subjective factors involved in it. The role of occlusion is multifactorial toward the denture success–retention, support, stability, preservation of the residual ridge and surrounding tissues/muscles, and undoubtedly the esthetics. The denture behaves different than natural teeth as it acts as one unit, where the force applied to a single denture tooth gets passed on to the whole denture. The muscle attachments and functional and parafunctional movements have their role to play in the denture success.

The other factor which has to be born in mind is the adaptability of the denture patients and also the role of tissue resiliency which is not objectively considered widely in literature. It is understood that an objective evaluation of the latter is clinically difficult and so is its role in denture settling and associated occlusal changes. That is why the denture patients were rightly termed as the denture acrobats.[17]

The balanced occlusion has been the preferred scheme for the stability of the denture, but yet questions have been raised and existed since decades regarding the clinical significance of BBO for denture success. Enter Bolus and Exit Balance' was mentioned in 1960's to emphasize the loss of occlusal balance during mastication. The deflective contacts may result in the tipping of the denture bases. But as the mastication time is much smaller than the other activities swallowing the bilateral balance would still be deisred. The aim being to minimise the deflective contacts. With use the balanced contacts originally created might be altered in the mouth but even then denture wearers can have clinical acceptance. This balance is not only dependent on the occlusal balance but also the lever balance created by the right tooth position (anteroposteriorly and mediolaterally and the occlusal height).[18,19] Various researches have concluded similar clinical results with other occlusal schemes, the denture teeth do not always contact, and the absence of interruptive and deflective contacts is what has been desired during function. The occlusal scheme pertaining to the above will fulfill the roles of retention and stability. Even if lost during function, the BBO may be helpful during seating during terminal arc of closure. The time and effort while preparing dentures with a balanced occlusion and the lateral forces which exist on working/nonworking sides are the areas which require evidence for the preference of BBO. Considering the Muller Devan's principle as an important parameter of success, this attempt has been made to look into more evidence related to the scheme which is clinically satisfactory and also maintains the integrity of the residual ridge and the muscles of mastication. The angle/direction

and amount of forces associated to various schemes and its effect on lever balance, if known, can help choose the occlusal scheme not only by subjective preferences but also based on biomechanical principles.[20,21]

This systematic review has been taken up with an aim of acquiring evidence for the choice of occlusion in complete denture prosthesis. The null hypothesis being balanced and nonbalanced occlusion schemes is similar in providing the denture-related satisfaction, and no difference exists in resorption rates and long-term consequences. The authors tried to explore more of the qualitative and objective studies done in association with complete denture prosthesis.

METHODOLOGY

This review was done using the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

Search policy
Literature that investigated into complete denture occlusion was searched using the predetermined search policy of PRISMA guidelines. The search policy was based on a Population, Intervention, Comparison, Outcome, and Study Design framework, and it is depicted in Table 1. The search keywords such as complete denture occlusion, balanced occlusion, bilateral balanced occlusion, lingualised occlusion, occlusal schemes for complete dentures, canine guided occlusion, effect of tissue resilience, and denture occlusion were used. It resulted in 215 articles for "balanced occlusion," 713 for "occlusal schemes," 59 for "CGO in complete dentures," 27 for "LO in CD," 121 for "occlusal scheme in CD," 1135 for "complete denture occlusion," 158 for comparison in CD occlusion, and 25 for the BO in CD making a total of 2448 studies.

An electronic search of studies published till September 2019 in PubMed, Science Direct, Google Scholar, Cochrane Central Register of Controlled Trials, and EBSCOhost were included. The journals hand searched were the *Journal of*

Prosthetic dentistry and the *Journal of Indian Prosthodontic Society*; cross references and bibliography were also referred to.

Inclusion and exclusion criteria
Abstracts and full research manuscript *in vivo* original studies related to occlusal schemes were read thoroughly, and the following inclusion and exclusion criteria are depicted.

Inclusion criteria
- Controlled clinical trial/randomized clinical trial
- Crossover trials
- Prospective and retrospective studies
- Objective and subjective tests
- Articles in English language
- Presence of follow-up period after insertion
- Use of anatomic or modified anatomic teeth.

Exclusion criteria
- Case report and case series
- Review articles
- Animal studies
- *In vitro* studies
- Use of nonanatomic teeth for the denture fabrication
- Other language articles
- Implant-associated denture occlusion.

Quality assessment
Articles were read thoroughly to assess methodology, randomization, sample size, control group, blinding of participants and personnel, quality of life, retention, and stability. The assessment was first done independently, and then, discussions were done among the reviewers to include or exclude the studies and to elaborate on missing data. The Cochrane Collaboration tool was used as an aid. Risk of bias was estimated as low, medium, or high based on the Cochrane risk of bias tool RoB2.0 and robvis (Chart 3 shows the use of robvis).[22]

Data extraction
The data information from published articles was collected in the needed format to include the information such as year of publication, type of study, type of occlusal schemes compared, test methodology used, sample size, assessment of retention, stability, and other factors of denture quality assessment and period of follow-up[15,23-36] [Table 2].

RESULTS

The steps of literature search were mainly identification, screening, eligibility, and inclusion or exclusion as suitable. Both reviewers did an independent search, and conclusions were reached by mutual discussions on the selected articles [Table 3].

Table 1: Population, Intervention, Comparison, Outcome, and Study Design search policy

PICOS	Description
Population	Complete denture wearer
Intervention	Occlusal scheme using anatomic/modified anatomic teeth
Comparison	Among occlusal schemes - BBO, LO, CG, and few other unbalanced schemes
Outcome	Masticatory efficiency, quality of life, satisfaction, adjustment time, postoperative problems, and long-term objectives
Study design	A systematic review

PICOS: Population, Intervention, Comparison, Outcome, and Study Design, BBO: Bilateral balanced occlusion, LO: Lingualized occlusion, CG: Canine guidance

DISCUSSION

Most of the studies included have been crossover studies, and these trials decrease the intersubject response variations due to reasons such as masticatory strength and unrealistic expectations. Most of the included crossover studies have used the same denture base which would omit the duplication errors (Khamis and Hussein method). At the same time, there exists a carryover effect with no washout period, which may result in reporting bias from the patients' response.[2,24,35] Some studies used single blinding when examiners were also involved in the denture construction whereas some studies were double blinded.[15,31]

The patient satisfaction was considered as the primary outcome to be tested, and the methods used have been subjective questionnaire formats related to denture-related satisfaction variables, Visual Analog Scale, Likert scale, oral health-related quality of life assessed using the Oral Health Impact Profile (OHIP), OHIP-edentulous adults, German Society for Dentistry and Oral Medicine for Functional and Diagnostic Therapy, and other rating formats [Table 2]. Tests for retention and stability were based on examiner skills[35] or Kapur index.[36]

Objective analyses have been performed for the masticatory forces, masticatory efficiency, and the stress and strain on the ridge, and EMG studies for the muscle activity have been done. Masticatory function was assessed by food particle size estimation using sieve method, colorimetric determination, optical scanning, biting force, or weight loss of viscoelastic food. Dentures with CGO were preferred more for certain food products such as carrots and meat. BO and LO were found to reduce selective food avoidance and physical disability aspects of patient satisfaction. More dislodging forces in BBO could cause patients to avoid some foods causing an unpleasant eating experience.[25] No difference in the masticatory efficiency was reported among various schemes,[17,22,25] and on the contrary, the efficiency is more ridge dependent.[24,25] In poor residual ridge conditions, LO was preferred by patients for acceptable stability and masticatory efficiency and retention. It allows modifications to adapt to various ridge types, elimination of lateral interferences, and settling without cuspal interferences.[11,31] LO was also associated with a better lever balance and hence more controlled forces.[14]

MO has been reported for the requirement of more adjustment time and more chairside corrections; it compromises on esthetics and masticatory efficiency with no special benefits. Anatomical tooth forms were found more efficient for chewing efficiency and denture adaptation; hence, the present review explored the latter and schemes with modified anatomic teeth.[1,11] An *in vitro* study on resilient edentulous jaw simulator was carried out for pressure analysis of various occlusal schemes to check for pressure on nonworking side by unilateral chewing. Pressure sensors and multichannel electronic strain indicators were used to check for pressure on the ridge under BBO, LO, and MO. The pressure in MO was found the least and almost similar in BO and LO.[37] Results were found statistically equivalent for BBO and LO. Being an *in vitro* study, this was excluded.

Anterior tooth group function and CGO have been mentioned for the efficiency for chewing. The points to be explored further are, the effects on denture retention and transfer of occlusal stresses. Some researchers have named these as 'Lateral occlusal guidance studies' where canine or premolar guided occluion is preferred to bilateral balance.[38] CGO was preferred for esthetics, phonetics, masticatory function, and retention in a crossover study with 50 subjects (10 dropouts) where all subjects preferred CGO, but a greater adjustment time was involved.[31,39] In another study,[11] similar results were concluded. Either a separate denture was fabricated or only the occlusal scheme was modified by alteration of canines. The CGO is the preferred scheme in dentulous patients for the well-known reason of discussion of posterior teeth during lateral movements, better esthetics, and lesser and easier fabrication time. A reduced muscle activity was explored, with no negative influence on lateral stability or higher resorption rates.

Little difference was found clinically among various occlusal schemes, so if the time taken for BBO is taken into consideration, the application of the same on a regular clinical basis is questionable. LO has been proved equally accepted but has not been taken as a control group in any of the comparisons. Scientific data for resorption patterns were not found in any of the studies, and a trend of subject dropouts might exist in prospective studies. A trend toward studies for the CGO has been comparatively more in the near past, and related literature was found only after the year 2000 [Chart 1]. The studies related to CGO are crossover trials which make them more valued, but none of the comparisons have been made with LO dentures. LO can provide the same freedom of movement as in neutrocentric or MO, even in cases of weak muscle engrams and with a better functional efficiency. The discrepancies in studies' results might occur due to certain factors like- clinician's technique or interoperator variability, tooth material and form selected, and various patient factors (ridge type, resilience and

Table 2: The Included studies of the systematic review

Author	Title/type	Occlusal schemes chosen for comparison study	Methods used for the study	Period of study	Sample size	Risk of bias	Conclusion By the authors
Suguru Kimoto 2006	Prospective Clinical Trial Comparing Lingualised Occlusion to Bilateral Balanced Occlusion in Complete Dentures: A Pilot Study	BBO & LO 20 degree semianatomic teeth for both	VAS Sieve test for masticatory efficiency	2 months after denture insertion	14 each	Low	Patients with LO expressed greater satisfaction. Ridge height and masticatory performance were reported to be related
Guido Heydecke 2007	Patient ratings of chewing ability from a randomized crossover trial: Lingualised vs. first premolar/canine-guided occlusion for complete dentures cross over trials	LO, first premolar or canine guidance set up.	VAS	Semi anatomic teeth for LO with facebow records, Anatomic teeth for CG without facebow records 3 months	20	Low	Better with CG,50 % of subjects and 25% no preference Anatomic teeth better for hard foods. No extra benefits with facebow transfer reported
Arcelino Farias Neto 2010	Masticatory efficiency in denture wearers with bilateral balanced occlusion and canine guidance double-blinded controlled crossover clinical trial	BBO and CG Anatomic teeth	Patient rating format Colorimetric test with beads	3 months & 6 months	24	low	Bilateral balanced occlusion does not improve the masticatory efficiency
Yuichi Matsumaru 2010	Influence of mandibular residual ridge resorption on objective masticatory measures of Lingualised and fully bilateral balanced denture articulation	Either LO or BBO RR also considered	Maximum force using pressure sensitive film, 5 to 120 Mpa Sieve test for masticatory performance Sirognathograph analyzing system for mandibular movements.	1 ½ years	22	low	LO is a preferred occlusal scheme for patients with severe resorption
A. G. Paleari 2012	A cross-over randomized clinical trial of eccentric occlusion in complete dentures	BBO and CG with 33 degree teeth	Questionnaire by celebic and Knezovic Zlataric Kienesiograph and Kolmogorov Smirnov test	30 days for each scheme	22 each	low	No influence of any scheme until the resiliency of ridge is normal
Mohhamadjavad Shirani 2013	Comparisons of Patient Satisfaction Levels with Complete Dentures of Different Occlusions: A Randomized Clinical Trial	BBO,LO,BO with 30 degree teeth	OHIP-EDENT	6 weeks	15 patients each with all three types of schemes	Low	BO and LO can improve food avoidance and physical disability aspects Of patient satisfaction.
Abdul Razzaq Ahmed 2013	Masticatory efficiency between balanced and Lingualised Occlusion in complete denture wearers	BBO & LO (20 degree semianatomic)	Sieve method		30 each	Low	Masticatory efficiency higher in LO

Cont...

Table 2: Continued....

Author	Title/type	Occlusal schemes chosen for comparison study	Methods used for the study	Period of study	Sample size	Risk of bias	Conclusion By the authors
Faten S Abbas 2016	Colorimetric comparative analysis of masticatory efficiency In complete denture wearers with two different occlusal concepts. Controlled crossover clinical trial	BBO and CGO A crossover study	Questionnaire and Colorimetric method with the beads for masticatory efficiency.	1 month	20	Low	No difference in Patient satisfaction with both schemes Adapts with time Mean values of satisfaction were more for CGO but statistically not significant.
Oliver Schierz 2 0 1 6	Influence of guidance concept in complete dentures on oral health related quality of life – Canine guidance vs. bilateral balanced occlusion A Randomized crossover trial	CGO & BBO	OHRQol OHIP OHIP-EDENT	3 months post each occlusal scheme	Block randomization of 19 subjects	Low	No difference of clinical significance
Muzamal Maqsood Butt 2016	Comparison of occlusal schemes in complete denture patients RCT	BBO & LO	Sieve method for masticatory performance	1 month	60	low	masticatory efficiency similar
Yasuhiko Kawai 2 0 1 7	A double blind randomized clinical trial comparing Lingualised and fully bilateral balanced posterior occlusion for conventional complete dentures	LO, BBO	VAS OHRQol OHIP	Baseline 3 months 6 months	30 each	Low	LO preferred in resorped ridges , in healthy ridges similar results
Hedaiat Moradpoor 2017	Patient Satisfaction with Occlusal Scheme of Conventional Complete Dentures: A Randomized Clinical Trial (Part II)	PGFO with BBO,BO,LO	OHIP-EDENT VAS	1 & 3 months post insertion	30	Low	PGFO had lower satisfaction in terms of quality of life
Vijaya Lakshmi Bolla 2017	Comparison of patient satisfaction in complete denture patients with different occlusal schemes	BBO & CG	Likert scale for patient satisfaction	24 hrs & 3 months	10 each	Bias might have arisen due to single blinding No crossover	Initial adaptation with BBO is better than CG Masticatory efficiency was found similar
D Maxwell 2017	Correlation of masticatory muscle activity with masticatory ability in complete denture patients with canine guidance and balanced occlusion crossover trial	BO & CG	Masticatory ability -questionnaire EMG- superficial masseter & temporalis	30 days	10	High due to sample size Single blinding blinding Cross over reduces reasons of bias like mastication strength	Better with CG 70% masticatory ability CG had lower EMG values.

Cont...

Table 2: Continued....

Author	Title/type	Occlusal schemes chosen for comparison study	Methods used for the study	Period of study	Sample size	Risk of bias	Conclusion By the authors
Hedaiat Moradpoor 2018	Patient Satisfaction with Occlusal Scheme of Conventional Complete Dentures: A Randomized Clinical Trial (Part I)	BBO,BO and LO	OHIP-EDENT VAS	1 & 3 months post insertion	30 each	Low	BO is as effective as LO LO & BO superior to BBO
Silvia Brandt 2019	Prospective clinical study of bilateral balanced occlusion (BBO) versus canine-guided occlusion (CGO) in complete denture wearers	CGO and BBO Anatomic teeth	Questionnaire based A crossover study	3 months 6 months	20 each 10 dropouts	Low Double blinding Crossover Calibration of examiners done	Canine guided was preferred for esthetics and phonetics by patients. Overall results were similar
Ana Carolina Pero 2019	Masticatory function in complete denture wearers varying degree of mandibular bone resorption and occlusion concept: canine-guided occlusion versus bilateral balanced occlusion in a cross-over trial	BBO and CGO 33 degree anatomic teeth	VAS for masticatory ability Sieve method for masticatory performance Gnatodynamometer for maximum occlusal force	3 months	23 for group 1 BBO to CG & 19 for the group 2 CG to BBO	Only Women participants. Possibility Sampling bias	CG represents a viable alternative to BBO Better results in retention and stability for CGO. Masticatory performance was dependent on ridge regardless occlusal guidance.

Table 3: Based on the search policy

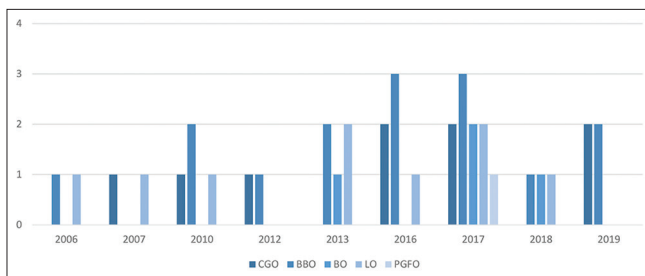| Serial number	Data number	Remarks
A	Identification	
1	2448	Using PubMed, EBSCOhost, and Google Scholar database searching
B	Screening	
1	1896	Research manuscripts were excluded as they were irrelevant or data were unavailable or due to repetition. Some were systemic review articles on similar concepts.
2	522	Full-text articles were assessed for eligibility
3	478	Articles were excluded, as they were case reports and review articles or associated to implant dentures. Some articles spoke of general well-being but not a specific occlusal scheme. Articles with use of nonanatomic teeth and flat/monoplane occlusal schemes were excluded
C	Eligibility	
1	74	Full-text articles selected
2	57	Full-text articles were excluded for the following reasons: retention and stability were not reported and the comparisons were not done with different entities
D	Inclusion	
1	17	Studies were included in the present systematic review

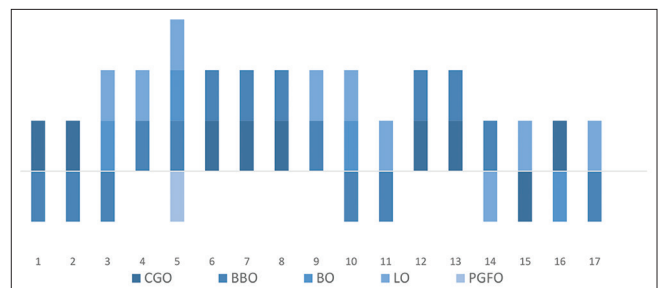**Chart 1:** Timeline of clinical trials associated with selected occlusal schemes

Chart 2: Representation of subjects, preference for various occlusal schemes

unrealistic or realistic expectations.). More scientific evidence for preference of certain schemes in specific situations and their long-term effect on ridge resorption would be beneficial. Studies based on finite element analysis for complete denture can be explored and have scope for future.[40]

CONCLUSIONS

Hypothesis was found partially correct that all schemes, if wisely used, can bring out good clinical results. No scheme is more superior to the other when using the anatomic tooth forms [Chart 2]. The part of hypothesis regarding the resorptive rates is difficult to be supported with enough evidence as there are no prospective studies with the different occlusal schemes. There is scope for

more evidence-based research for the preferred occlusal scheme in different ridge relations and comparative trials of CGO with LO. Balanced occlusion is one of the preferred choices for occlusal schemes but not for all the ridges. Lingualized occlusion can be helpful in resorbed ridges for the masticatory efficiency and even in providing bilateral balance. CGO is the most preferred occlusion scheme for dentulous situations and needs more evidence-based research related to its effects on denture stability.

The complete denture prosthodontics is the most difficult and skill requiring area to bring out the best rehabilitation in an edentulous patient. The wise choice of varied parameters is sure to result in clinical success.

Conflicts of interest
There are no conflicts of interest.

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	Risk of bias domains					
Study	D1	D2	D3	D4	D5	Overall
Kimoto 2006	+	−	+	+	+	+
Heydecke 2007	+	−	+	+	+	+
Matsumaru 2010	+	+	+	+	+	+
Farias 2010	+	+	+	+	+	+
Paeleri 2012	+	+	+	+	+	+
Ahmed 2013	+	+	+	+	+	+
Shirani 2013	+	+	−	+	+	+
Butt 2016	+	−	+	+	+	+
Schierz 2016	+	+	+	+	+	+
Abbas 2016	+	+	+	+	−	+
Maxwell 2017	+	+	−	+	+	+
Vijaylaxmi 2017	+	−	+	+	−	○
Moradpur 2017	+	+	+	+	+	+
Kawai 2017	+	+	+	+	+	+
moradpur 2018	+	+	+	+	+	+
carolina 2019	+	−	+	−	+	+
Brandt 2019	+	+	+	+	+	+

Domains:
D1: Bias due to randomisation.
D2: Bias due to deviations from intended intervention.
D3: Bias due to missing data.
D4: Bias due to outcome measurement.
D5: Bias due to selection of reported result.

Judgement
− Some concerns
+ Low
NA

Chart 3: Risk of bias domain

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