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REVIEW

EFFECTIVENESS OF CORDLESS TECHNIQUES IN GINGIVAL DISPLACEMENT. A SYSTEMATIC REVIEW AND META-ANALYSIS

Eficacia de las técnicas sin hilos en el desplazamiento gingival. Revisión sistemática y metanálisis

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ABSTRACT

Objective: To compare the effectiveness of the conventional technique and cordless technique in gingival displacement.

Materials and Methods: A bibliographic search was carried out until August 2023, in the biomedical databases: *Pubmed/Medline, Cochrane Library, Scielo, Scopus and Google Scholar.* Included studies reporting the gingival displacement of vital teeth using the cordless and conventional techniques comprised clinical trials, articles in English and without time limits. The RoB 2.0 tool was used to assess the risk of the included studies and the GRADEPro GDT tool to assess the quality of the evidence and the strength of recommendation of the results.

Results: The preliminary search yielded a total of 489 articles, discarding those that did not meet the selection criteria, leaving only 15 articles. A total of fourteen articles entered a meta-analysis. It was found that the conventional technique caused better gingival (width) displacement than the cordless techniques, however, it caused more bleeding. Furthermore, among the wireless techniques, the one using polyvinylsiloxane obtained better results.

Conclusions: The literature reviewed suggests that the conventional technique resulted in a better gingival displacement (width) than the cordless techniques, however, it causes a greater periodontal injury.

Keywords: *Periodontal Diseases; Oral Surgical Procedures; Gingiva; Gingival Recession; Systematic Review; Meta-analysis*

RESUMEN

Objetivo: Comparar la efectividad de la técnica convencional y la técnica sin hilos en el desplazamiento gingival.

Materiales y Métodos: Se realizó una búsqueda bibliográfica hasta agosto de 2023, en las bases de datos biomédicas: *Pubmed/Medline, Cochrane Library, Scielo, Scopus y Google Scholar.* Los estudios incluidos que informaron el desplazamiento gingival de dientes vitales utilizando técnicas sin hilos y convencionales comprenden ensayos clínicos, artículos en inglés y sin límites de tiempo. Se utilizó la herramienta RoB 2.0 para evaluar el riesgo de los estudios incluidos y la herramienta GRADEPro GDT para evaluar la calidad de la evidencia y la fuerza de recomendación de los resultados.

Resultados: La búsqueda preliminar arrojó un total de 489 artículos, descartando aquellos que no cumplieron con los criterios de selección, quedando solo 15 artículos. Un total de catorce artículos entraron en el metanálisis. Se encontró que la técnica convencional provocó un mejor desplazamiento gingival (ancho) que las técnicas sin hilos; sin embargo, provocó más sangrado. Además, dentro de las técnicas sin hilos, la que utiliza polivinilsiloxano obtuvo mejores resultados.

Conclusión: La literatura revisada sugiere que la técnica convencional resultó en un mejor desplazamiento (ancho) gingival que las técnicas sin hilos; sin embargo, provoca una mayor lesión periodontal.

Palabras Clave: *Enfermedades Periodontales; Procedimientos Quirúrgicos Orales; Encía; Recesión gingival; Revisión sistemática; Metaanálisis.*

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INTRODUCTION

Currently, the demand for aesthetic prosthetic restorations using ceramic restorations, is increasing.[1] However, an inadequate adaptation of these restorations with intracrevicular margins can cause problems such as the accumulation of biofilm, secondary caries and inflammation of the periodontal tissue.[2,3]
An accurate impression plays a crucial role in the ultimate success and longevity of the treatment. Gingival displacement is considered as the key procedure to guarantee the precision of the impression.[4] Therefore, special attention should be paid to this treatment stage in order to provide accurate marginal fit of the restorations.[5]

The mechanical insertion of cord into the sulcus is a traditional technique used to displace gingiva.[6-8] It relies on physically pushing the free gingiva away from the preparation line. However, this technique is unable to control bleeding and crevicular fluid leakage,[2,6-8] therefore chemomechanical methods, using cords impregnated with hemostatic, vasoconstrictor or astringent agents were introduced.[2,3,6,9-14]
During cord insertion, pressure can damage the epithelial attachment[15] gingival bleeding, direct trauma to the sulcular epithelium, or gingival recession .[8]
Currently, cordless techniques have been introduced to increase patient comfort, simplify the gingival displacement process, reduce pain, and minimize invasion of periodontal tissue.[6-8,15,16] Cordless displacement systems are available as a paste or foam that is injected into the sulcus,[7] eliminating the need to physically compress the material and minimizing injury.[6-8]

The expansion of these materials mechanically displaces the gingiva and absorbs crevicular fluid. Several clinical trials have compared gingival displacement produced by corded and cordless techniques.[2,3,10-14]

Unfortunately, no definitive clinical recommendations have been made regarding the suitability of specific materials and techniques for gingival displacement. This situation might arise due to the variability of the materials tested and methods of sulcus width measurements.[5,16] Therefore, the objective of this systematic review and meta-analysis was to compare the effectiveness of cordless and traditional technique in gingival displacement.

MATERIALS AND METHODS

Protocol and registration

The protocol for this systematic review was defined a priori by all authors and was prepared following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guideline.[17]
In addition, this protocol was registered in the Prospective International Register of Systematic Reviews (PROSPERO) with the registration number CRD42021252839.

To prepare and structure this review, the focused question was formulated using the PICO format (population, intervention, outcomes and results) as detailed below:
- Population: Vital teeth of adult humans.
- Intervention: Gingival displacement with the cordless technique.
- Comparison: Gingival displacement with the conventional technique.

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- Outcomes: Sulcular Height, Sulcular Width, Bleeding and Gingival Recession.

Focused question (PICO)

Is there a difference in gingival displacement with the cordless technique in relation to the conventional technique?

Search and selection of studies

For the present systematic review, a bibliographic search was carried out in 5 electronic databases (*Pubmed/Medline, Cochrane Library, Scopus, Scielo* and *Google Scholar*) until August 2023; combining keywords and subject titles according to the thesaurus of each database: *"human", "gingival tissues", "intracrevicular margin", "teeth", "tooth", "incisor", "canine", "premolar", "molar", "astringent retraction paste", "gingival retraction paste", "retraction paste", "chemico mechanical", "gingival paste", "cordless", "retraction cords", "cord" and "mechanical"*. The search strategies of each of the databases are found in Table 1.

Additionally, additional relevant literature was included after a hand search of the reference lists of the final included articles.

The search in the electronic database was carried out by two authors (FC and HA) independently, and the final inclusion decision was made according to the following criteria: Clinical trials, in English, without time limit and reporting the gingival displacement (height and width or space of the groove) of vital teeth using cordless and conventional techniques. Articles that were prospective studies and unpublished studies were excluded.

Data extraction

A predefined table was used to extract data from each eligible study, including: author(s), year of publication, type of study, country where the study was conducted, number of patients, mean age and age range, type of teeth treated, tooth preparation, periodontal status, study groups, number of patients and teeth per study group, impression material, impression tray type, type of plaster, measuring instrument, sulcular height, sulcular width and clinical parameters (bleeding and gingival recession).

From each eligible study, two investigators (EI and JR) independently extracted information and all disagreements were resolved by discussion with a third reviewer (LA).

Risk of bias (RoB) assessment

The RoB of the included studies was independently assessed by two calibrated authors (EI and JR) (k = 0.98) using the Cochrane Group´s RoB 2.0 tool[18] and all disagreements were resolved by discussion with a third reviewer (LA).

According to this tool, clinical trials are evaluated in 5 domains:

Randomization process, deviations from plan ned interventions, missing outcome data, outcome measurement, and selection of the results report; to later be classified as: High Risk of Bias, Bias with some concerns or Low Risk of Bias.

Analysis of results

Data from each study were entered and analyzed in RevMan 5.3 (Cochrane Group, UK); using the mean and standard deviation and frequency as a measure, in a random

effects model with a 95% confidence interval. Additionally, a GRADE analysis was performed using the guideline development tool (GRADEPro GDT) (McMaster University and Evidence Prime Inc., Canada).

RESULTS

Selection of studies

The electronic and manual search strategy yielded a total of 520 articles, excluding 40 duplicates (Figure 1). Titles were read and 463 were excluded, leaving 17 potentially eligible full-text articles. }

Abstracts were read, discarding 2 articles that did not present a control group, which resulted in 15 clinical trials that met the eligibility criteria for qualitative synthesis and 14 for quantitative analysis (meta-analysis). The reasons for exclusion of the studies[3,19] are found in Table 2.

Characteristics of included studies

Overall, 15 clinical trials were included,[2,10-14,20-28] of which eight were crossover[2,12-14,23,24,26,27] and seven were parallel.[10,11,20–22,25,28] All studies re-ported that the total number of patients ranged between 10 and 45 and that the number of treated teeth ranged between 10 and 90. Two studies[10,20] reported that the mean age of the patients ranged between 28 and 49.8 years, and 13 studies [10–14,20–23,25–28] reported a range of 18 to 54 years of all patients (Table 3).

The countries where the studies were carried out were: New Zealand,[21] India,[2,10–12,14,22,23,25–28] Egypt,[20] Indonesia[24] and Iran.[13]

Twelve studies[2,10,12–14,20–23,26–28] reported the teeth treated in the studies (incisors, canines, premolars and molars). All studies reported that the treated teeth were healthy. Seven studies[14,21–23,26–28] mentioned that the included teeth were without any preparation and 8 studies,[2,10–13,20,24,25] that they were in preparation for the performance of an oral rehabilitation (Table 3).

Eleven studies[2,11–13,20–22,24,25,27,28] reported the use of a paste as a cordless technique, two studies[14,26] the use of a gel, five studies[10,11,14,20,28] the use of polyvinylsiloxane, one study[23] the use of Aguasil, one study 10 the use of diode laser and three studies[23,25,27] did not use a cord. In five studies[11,20,21,23,28] the height of the sulcus was reported,[14] studies[2,10–14,21–28] the width of the sulcus, three studies[12,13,28] the gingival recession and five studies,[12,14,20–22] the number of patients who reported bleeding or hemorrhage after the impression (Table 3).

Risk of bias analysis of studies

Eight studies[14,21,23–28] were at high risk of bias and seven studies[2,10–13,20,22] were at low risk of bias (Figure 2).

Synthesis of the results (Meta-analysis)

The effectiveness of cordless techniques in gingival displacement in terms of sulcular height, sulcular width, bleeding and gingival recession was determined in three,[11,20,28] twelve.[2,10–14,22,24–28] four [12,14,20,21] and two[13,28] studies, showing that there was a statistically significant difference for sulcular width (p = 0.005, I^2 = 99%, MD = 0.12 [0.03 – 0.2]) and bleeding (p = 0.02, I^2 = 77%, MD = 20.7 [1.69 – 253.44]); and there was no statistically significant difference for sulcular height (p = 0.62, I^2 = 96%, MD = -0.1 [-0.51 – 0.3]) and gingival recession (p= 0.07, I^2 = 85%, MD = 0.07 [-0.01 – 0.14]) (Figure 3).

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Subgroup synthesis

- Paste *versus* traditional technique

The effectiveness of paste as a cordless technique on gingival displacement in terms of sulcular height, sulcular width, bleeding, and gingival recession; was determined in three,[11,20,28] nine,[2,11–13,22,24,25,27,28] three[12,20,21] and two[13,28] studies, sho-wing that there was a statistically significant difference for sulcular width (p= 0.04, I^2= 99%, MD = 0.1 [0.01 – 0.18]) and gingival recession (p= 0.03, I^2= 80%, MD = 0.07 [0.01 – 0.14]); and there was no statistically significant difference for sulcular height (p = 0.8, I2 = 97%, MD = 0.06 [-0.39 – 0.51]) and bleeding (p= 0.31, I^2 = 83%, MD = 4.27 [0.25 – 71.92]), (Figure 3).

- Polyvinylsiloxane *versus* traditional technique

The effectiveness of polyvinylsiloxane as a cordless technique on gingival displacement in terms of sulcular height, sulcular width and bleeding; was determined in three,[11,20,28] four[10,11,14,28] and two[14,20] studies, showing that there was a statistically significant difference for sulcular width (p = 0.05, I^2 = 95%, MD = 0.1 [-0.00 – 0.2]) and bleeding (p = 0.001, I^2 = 0%, MD = 8.33 [2.34 – 29.64]); and there was no statistically significant difference for sulcular height (p = 0.62, I^2 = 96%, MD = -0.1 [-0.51 – 0.3]) (Figure 3).

Figure 1. PRISMA flow chart of the process of inclusion and exclusion of studies in the systematic review

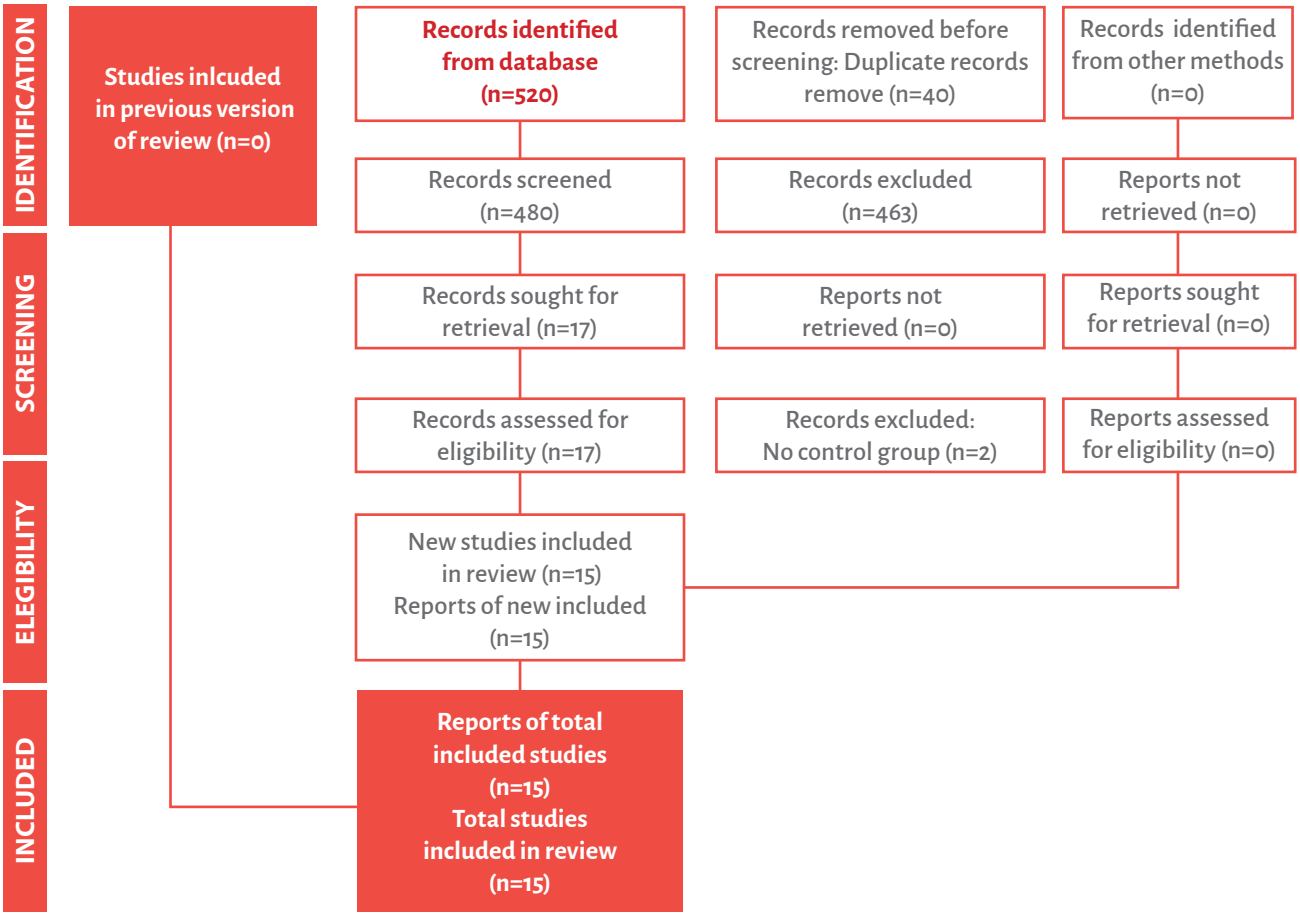


Figure 2. Risk of bias of included studies

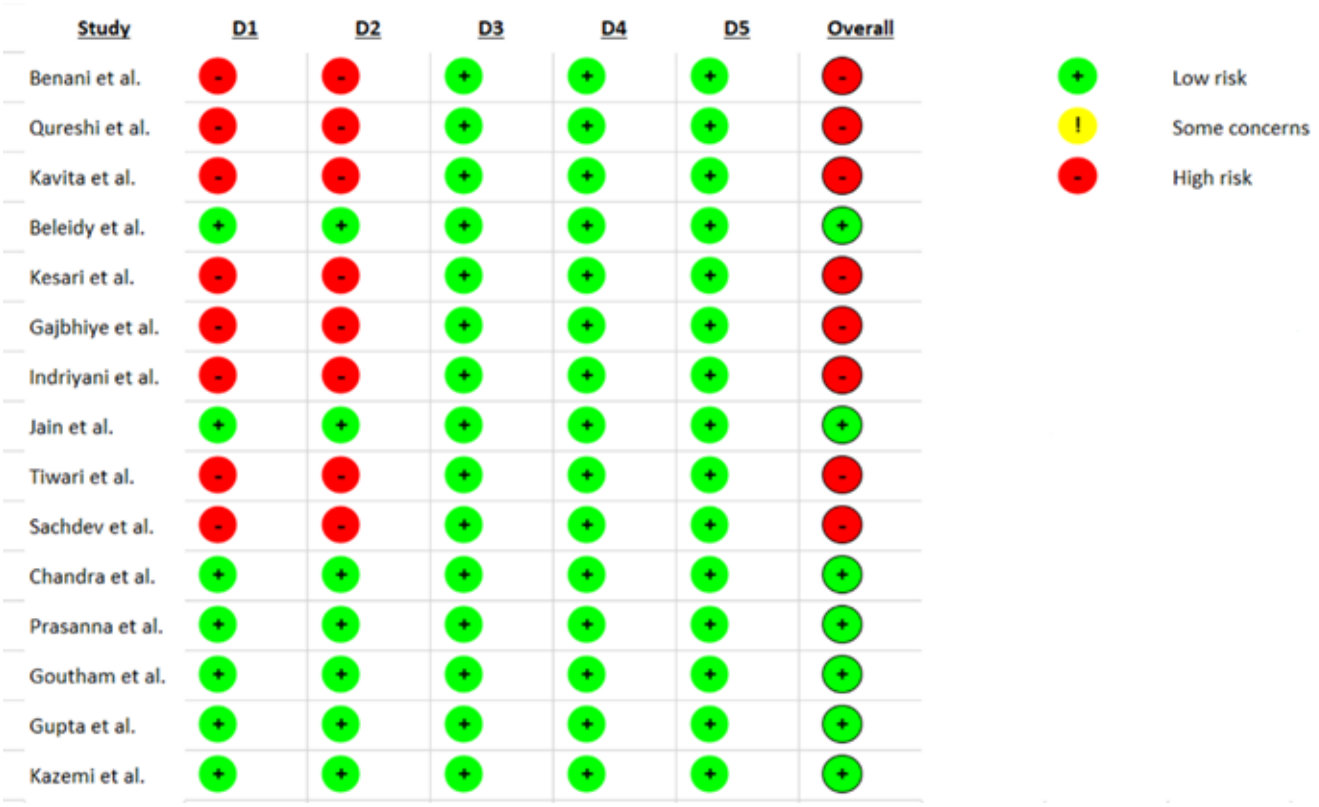
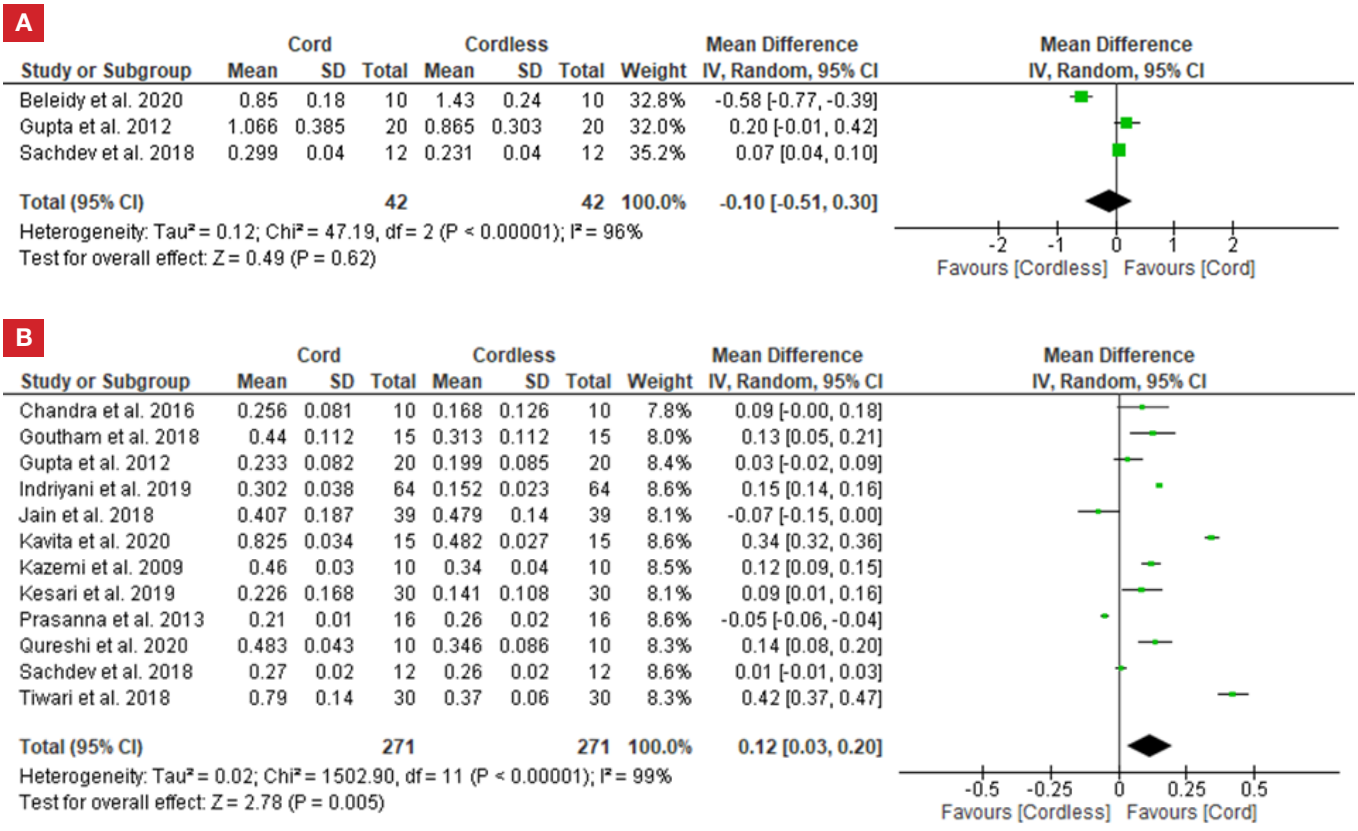


Figure 3. Forest plot of the effectiveness of cordless technique in gingival displacement.



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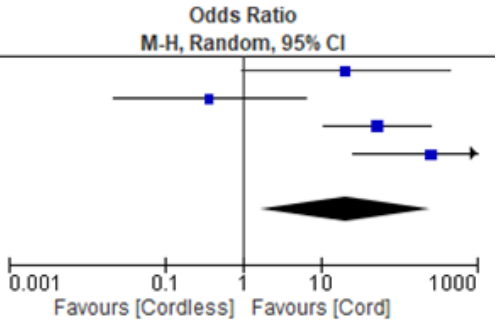
C

Study or Subgroup	Cord Events	Cord Total	Cordless Events	Cordless Total	Weight	Odds Ratio M-H, Random, 95% CI
Beleidy et al. 2020	5	10	0	10	22.0%	21.00 [0.97, 453.91]
Bennani et al. 2020	1	5	2	5	23.2%	0.38 [0.02, 6.35]
Jain et al. 2018	29	39	2	39	29.1%	53.65 [10.90, 264.17]
Tiwari et al. 2018	27	30	1	30	25.7%	261.00 [25.57, 2664.03]
Total (95% CI)		**84**		**84**	**100.0%**	**20.70 [1.69, 253.44]**
Total events	62		5			

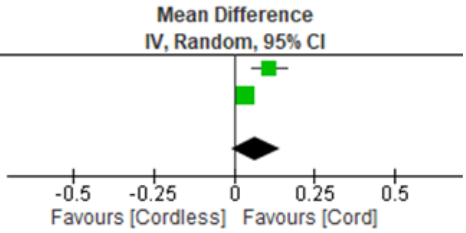
Heterogeneity: Tau² = 4.95; Chi² = 13.33, df = 3 (P = 0.004); I² = 77%
Test for overall effect: Z = 2.37 (P = 0.02)



D

Study or Subgroup	Cord Mean	Cord SD	Cord Total	Cordless Mean	Cordless SD	Cordless Total	Weight	Mean Difference IV, Random, 95% CI
Kazemi et al. 2009	0.14	0.07	10	0.03	0.05	10	44.9%	0.11 [0.06, 0.16]
Sachdev et al. 2018	0.124	0.03	12	0.09	0.03	12	55.1%	0.03 [0.01, 0.06]
Total (95% CI)			**22**			**22**	**100.0%**	**0.07 [-0.01, 0.14]**

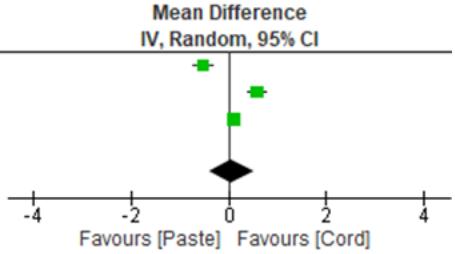
Heterogeneity: Tau² = 0.00; Chi² = 6.49, df = 1 (P = 0.01); I² = 85%
Test for overall effect: Z = 1.80 (P = 0.07)



E

Study or Subgroup	Cord Mean	Cord SD	Cord Total	Paste Mean	Paste SD	Paste Total	Weight	Mean Difference IV, Random, 95% CI
Beleidy et al. 2020	0.85	0.18	10	1.37	0.27	10	32.5%	-0.52 [-0.72, -0.32]
Gupta et al. 2012	1.066	0.385	20	0.484	0.195	20	32.8%	0.58 [0.39, 0.77]
Sachdev et al. 2018	0.299	0.04	12	0.195	0.04	12	34.7%	0.10 [0.07, 0.14]
Total (95% CI)			**42**			**42**	**100.0%**	**0.06 [-0.39, 0.51]**

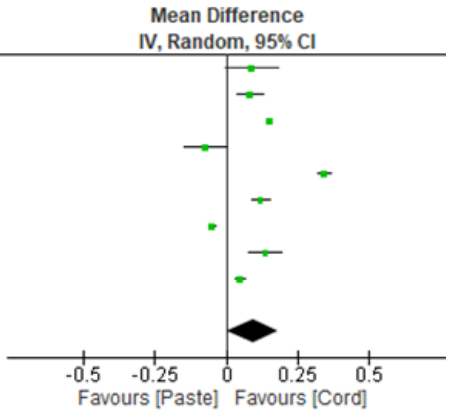
Heterogeneity: Tau² = 0.15; Chi² = 61.50, df = 2 (P < 0.00001); I² = 97%
Test for overall effect: Z = 0.25 (P = 0.80)



F

Study or Subgroup	Cord Mean	Cord SD	Cord Total	Paste Mean	Paste SD	Paste Total	Weight	Mean Difference IV, Random, 95% CI
Chandra et al. 2016	0.256	0.081	10	0.168	0.126	10	10.2%	0.09 [-0.00, 0.18]
Gupta et al. 2012	0.233	0.082	20	0.151	0.069	20	11.1%	0.08 [0.04, 0.13]
Indriyani et al. 2019	0.302	0.038	64	0.152	0.023	64	11.5%	0.15 [0.14, 0.16]
Jain et al. 2018	0.407	0.187	39	0.479	0.14	39	10.7%	-0.07 [-0.15, 0.00]
Kavita et al. 2020	0.825	0.034	15	0.482	0.027	15	11.4%	0.34 [0.32, 0.36]
Kazemi et al. 2009	0.46	0.03	10	0.34	0.04	10	11.3%	0.12 [0.09, 0.15]
Prasanna et al. 2013	0.21	0.01	16	0.26	0.02	16	11.5%	-0.05 [-0.06, -0.04]
Qureshi et al. 2020	0.483	0.043	10	0.346	0.086	10	10.9%	0.14 [0.08, 0.20]
Sachdev et al. 2018	0.27	0.02	12	0.22	0.02	12	11.4%	0.05 [0.03, 0.07]
Total (95% CI)			**196**			**196**	**100.0%**	**0.10 [0.01, 0.18]**

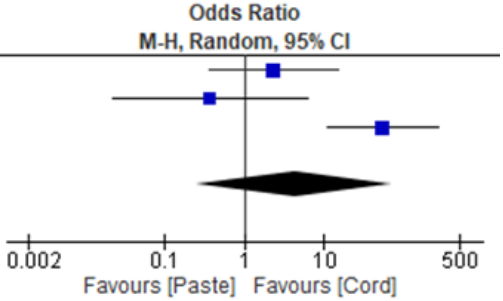
Heterogeneity: Tau² = 0.02; Chi² = 1289.96, df = 8 (P < 0.00001); I² = 99%
Test for overall effect: Z = 2.08 (P = 0.04)



G

Study or Subgroup	Cord Events	Cord Total	Paste Events	Paste Total	Weight	Odds Ratio M-H, Random, 95% CI
Beleidy et al. 2020	5	10	3	10	34.9%	2.33 [0.37, 14.61]
Bennani et al. 2020	1	5	2	5	29.0%	0.38 [0.02, 6.35]
Jain et al. 2018	29	39	2	39	36.2%	53.65 [10.90, 264.17]
Total (95% CI)		**54**		**54**	**100.0%**	**4.27 [0.25, 71.92]**
Total events	35		7			

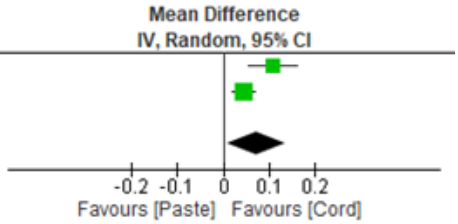
Heterogeneity: Tau² = 5.08; Chi² = 11.73, df = 2 (P = 0.003); I² = 83%
Test for overall effect: Z = 1.01 (P = 0.31)



H

Study or Subgroup	Cord Mean	Cord SD	Cord Total	Paste Mean	Paste SD	Paste Total	Weight	Mean Difference IV, Random, 95% CI
Kazemi et al. 2009	0.14	0.07	10	0.03	0.05	10	43.2%	0.11 [0.06, 0.16]
Sachdev et al. 2018	0.124	0.03	12	0.08	0.03	12	56.8%	0.04 [0.02, 0.07]
Total (95% CI)			**22**			**22**	**100.0%**	**0.07 [0.01, 0.14]**

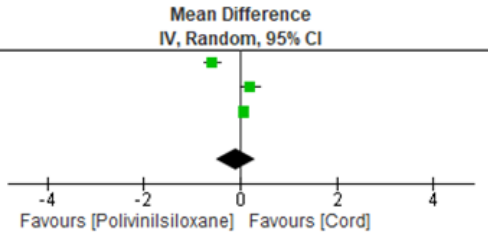
Heterogeneity: Tau² = 0.00; Chi² = 4.89, df = 1 (P = 0.03); I² = 80%
Test for overall effect: Z = 2.22 (P = 0.03)



I

Study or Subgroup	Cord Mean	Cord SD	Cord Total	Polivinilsiloxane Mean	Polivinilsiloxane SD	Polivinilsiloxane Total	Weight	Mean Difference IV, Random, 95% CI
Beleidy et al. 2020	0.85	0.18	10	1.43	0.24	10	32.8%	-0.58 [-0.77, -0.39]
Gupta et al. 2012	1.066	0.385	20	0.865	0.303	20	32.0%	0.20 [-0.01, 0.42]
Sachdev et al. 2018	0.299	0.04	12	0.231	0.04	12	35.2%	0.07 [0.04, 0.10]
Total (95% CI)			**42**			**42**	**100.0%**	**-0.10 [-0.51, 0.30]**

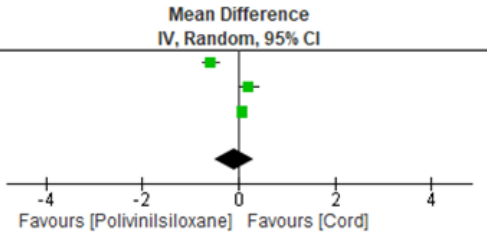
Heterogeneity: Tau² = 0.12; Chi² = 47.19, df = 2 (P < 0.00001); I² = 96%
Test for overall effect: Z = 0.49 (P = 0.62)



J

Study or Subgroup	Cord Mean	Cord SD	Cord Total	Polivinilsiloxane Mean	Polivinilsiloxane SD	Polivinilsiloxane Total	Weight	Mean Difference IV, Random, 95% CI
Beleidy et al. 2020	0.85	0.18	10	1.43	0.24	10	32.8%	-0.58 [-0.77, -0.39]
Gupta et al. 2012	1.066	0.385	20	0.865	0.303	20	32.0%	0.20 [-0.01, 0.42]
Sachdev et al. 2018	0.299	0.04	12	0.231	0.04	12	35.2%	0.07 [0.04, 0.10]
Total (95% CI)			**42**			**42**	**100.0%**	**-0.10 [-0.51, 0.30]**

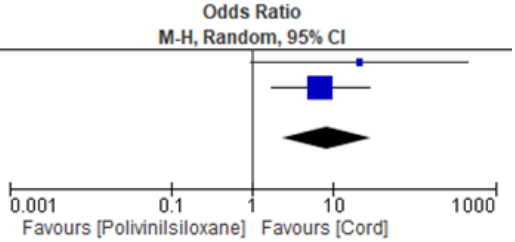
Heterogeneity: Tau² = 0.12; Chi² = 47.19, df = 2 (P < 0.00001); I² = 96%
Test for overall effect: Z = 0.49 (P = 0.62)



K

Study or Subgroup	Cord Events	Cord Total	Polivinilsiloxane Events	Polivinilsiloxane Total	Weight	Odds Ratio M-H, Random, 95% CI
Beleidy et al. 2020	5	10	0	10	17.1%	21.00 [0.97, 453.91]
Tiwari et al. 2018	27	30	17	30	82.9%	6.88 [1.71, 27.75]
Total (95% CI)		**40**		**40**	**100.0%**	**8.33 [2.34, 29.64]**
Total events	32		17			

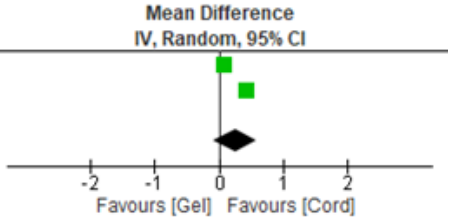
Heterogeneity: Tau² = 0.00; Chi² = 0.42, df = 1 (P = 0.51); I² = 0%
Test for overall effect: Z = 3.27 (P = 0.001)



L

Study or Subgroup	Cord Mean	Cord SD	Cord Total	Gel Mean	Gel SD	Gel Total	Weight	Mean Difference IV, Random, 95% CI
Kesari et al. 2019	0.226	0.168	30	0.141	0.108	30	49.8%	0.09 [0.01, 0.16]
Tiwari et al. 2018	0.79	0.14	30	0.37	0.06	30	50.2%	0.42 [0.37, 0.47]
Total (95% CI)			**60**			**60**	**100.0%**	**0.25 [-0.07, 0.58]**

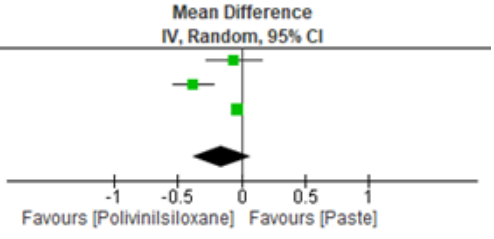
Heterogeneity: Tau² = 0.06; Chi² = 53.37, df = 1 (P < 0.00001); I² = 98%
Test for overall effect: Z = 1.51 (P = 0.13)



M

Study or Subgroup	Paste Mean	Paste SD	Paste Total	Polivinilsiloxane Mean	Polivinilsiloxane SD	Polivinilsiloxane Total	Weight	Mean Difference IV, Random, 95% CI
Beleidy et al. 2020	1.37	0.27	10	1.43	0.24	10	28.5%	-0.06 [-0.28, 0.16]
Gupta et al. 2012	0.484	0.195	20	0.865	0.303	20	32.9%	-0.38 [-0.54, -0.22]
Sachdev et al. 2018	0.195	0.04	12	0.231	0.04	12	38.6%	-0.04 [-0.07, -0.00]
Total (95% CI)			**42**			**42**	**100.0%**	**-0.16 [-0.39, 0.07]**

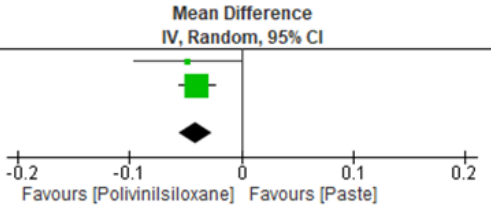
Heterogeneity: Tau² = 0.04; Chi² = 17.62, df = 2 (P = 0.0001); I² = 89%
Test for overall effect: Z = 1.33 (P = 0.18)



N

Study or Subgroup	Paste Mean	Paste SD	Paste Total	Polivinilsiloxane Mean	Polivinilsiloxane SD	Polivinilsiloxane Total	Weight	Mean Difference IV, Random, 95% CI
Gupta et al. 2012	0.151	0.069	20	0.199	0.085	20	10.0%	-0.05 [-0.10, -0.00]
Sachdev et al. 2018	0.22	0.02	12	0.26	0.02	12	90.0%	-0.04 [-0.06, -0.02]
Total (95% CI)			**32**			**32**	**100.0%**	**-0.04 [-0.06, -0.03]**

Heterogeneity: Tau² = 0.00; Chi² = 0.10, df = 1 (P = 0.76); I² = 0%
Test for overall effect: Z = 5.27 (P < 0.00001)



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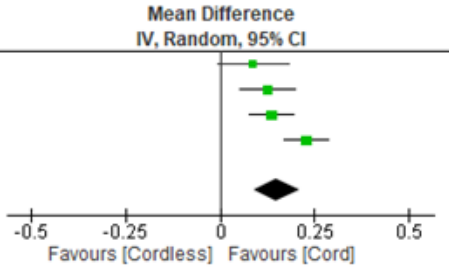
O

Study or Subgroup	Cord Mean	Cord SD	Cord Total	Cordless Mean	Cordless SD	Cordless Total	Weight	Mean Difference IV, Random, 95% CI
Chandra et al. 2016	0.256	0.081	10	0.168	0.126	10	20.0%	0.09 [-0.00, 0.18]
Goutham et al. 2018	0.44	0.112	15	0.313	0.092	15	24.4%	0.13 [0.05, 0.20]
Qureshi et al. 2020	0.483	0.043	10	0.346	0.086	10	27.8%	0.14 [0.08, 0.20]
Tiwari et al. 2018	0.79	0.14	30	0.56	0.09	30	27.8%	0.23 [0.17, 0.29]
Total (95% CI)			**65**			**65**	**100.0%**	**0.15 [0.09, 0.21]**

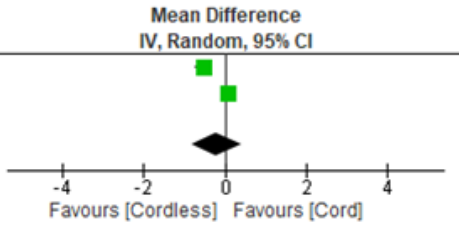
Heterogeneity: Tau² = 0.00; Chi² = 8.96, df = 3 (P = 0.03); I² = 67%
Test for overall effect: Z = 4.90 (P < 0.00001)



P

Study or Subgroup	Cord Mean	Cord SD	Cord Total	Cordless Mean	Cordless SD	Cordless Total	Weight	Mean Difference IV, Random, 95% CI
Beleidy et al. 2020	0.85	0.18	10	1.37	0.27	10	48.7%	-0.52 [-0.72, -0.32]
Sachdev et al. 2018	0.299	0.04	12	0.195	0.04	12	51.3%	0.10 [0.07, 0.14]
Total (95% CI)			**22**			**22**	**100.0%**	**-0.20 [-0.81, 0.41]**

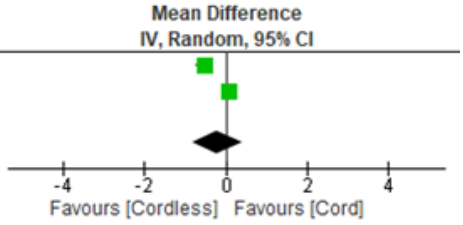
Heterogeneity: Tau² = 0.19; Chi² = 36.06, df = 1 (P < 0.00001); I² = 97%
Test for overall effect: Z = 0.64 (P = 0.52)



Q

Study or Subgroup	Cord Mean	Cord SD	Cord Total	Cordless Mean	Cordless SD	Cordless Total	Weight	Mean Difference IV, Random, 95% CI
Beleidy et al. 2020	0.85	0.18	10	1.37	0.27	10	48.7%	-0.52 [-0.72, -0.32]
Sachdev et al. 2018	0.299	0.04	12	0.195	0.04	12	51.3%	0.10 [0.07, 0.14]
Total (95% CI)			**22**			**22**	**100.0%**	**-0.20 [-0.81, 0.41]**

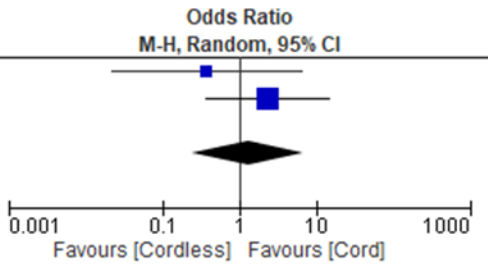
Heterogeneity: Tau² = 0.19; Chi² = 36.06, df = 1 (P < 0.00001); I² = 97%
Test for overall effect: Z = 0.64 (P = 0.52)



R

Study or Subgroup	Cord Events	Cord Total	Cordless Events	Cordless Total	Weight	Odds Ratio M-H, Random, 95% CI
Bennani et al. 2020	1	5	2	5	32.0%	0.38 [0.02, 6.35]
Beleidy et al. 2020	5	10	3	10	68.0%	2.33 [0.37, 14.61]
Total (95% CI)		**15**		**15**	**100.0%**	**1.30 [0.24, 6.92]**
Total events	6		5			

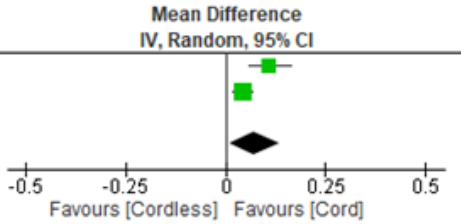
Heterogeneity: Tau² = 0.19; Chi² = 1.13, df = 1 (P = 0.29); I² = 12%
Test for overall effect: Z = 0.31 (P = 0.76)



S

Study or Subgroup	Cord Mean	Cord SD	Cord Total	Cordless Mean	Cordless SD	Cordless Total	Weight	Mean Difference IV, Random, 95% CI
Kazemi et al. 2009	0.14	0.07	10	0.03	0.05	10	43.2%	0.11 [0.06, 0.16]
Sachdev et al. 2018	0.124	0.03	12	0.08	0.03	12	56.8%	0.04 [0.02, 0.07]
Total (95% CI)			**22**			**22**	**100.0%**	**0.07 [0.01, 0.14]**

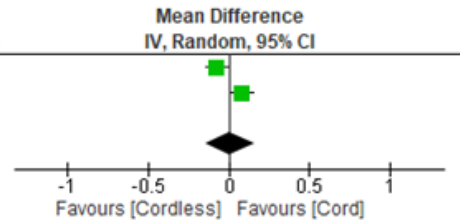
Heterogeneity: Tau² = 0.00; Chi² = 4.89, df = 1 (P = 0.03); I² = 80%
Test for overall effect: Z = 2.22 (P = 0.03)



T

Study or Subgroup	Cord Mean	Cord SD	Cord Total	Cordless Mean	Cordless SD	Cordless Total	Weight	Mean Difference IV, Random, 95% CI
Jain et al. 2018	0.407	0.187	39	0.479	0.14	39	49.9%	-0.07 [-0.15, 0.00]
Kesari et al. 2019	0.226	0.168	30	0.141	0.108	30	50.1%	0.09 [0.01, 0.16]
Total (95% CI)			**69**			**69**	**100.0%**	**0.01 [-0.15, 0.16]**

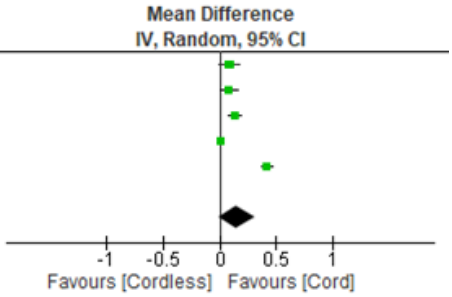
Heterogeneity: Tau² = 0.01; Chi² = 9.03, df = 1 (P = 0.003); I² = 89%
Test for overall effect: Z = 0.09 (P = 0.93)



U

Study or Subgroup	Cord Mean	Cord SD	Cord Total	Cordless Mean	Cordless SD	Cordless Total	Weight	Mean Difference IV, Random, 95% CI
Chandra et al. 2016	0.256	0.081	10	0.168	0.126	10	19.3%	0.09 [-0.00, 0.18]
Kesari et al. 2019	0.226	0.168	30	0.141	0.108	30	19.8%	0.09 [0.01, 0.16]
Qureshi et al. 2020	0.483	0.043	10	0.346	0.086	10	20.1%	0.14 [0.08, 0.20]
Sachdev et al. 2018	0.27	0.02	12	0.26	0.02	12	20.6%	0.01 [-0.01, 0.03]
Tiwari et al. 2018	0.79	0.14	30	0.37	0.06	30	20.2%	0.42 [0.37, 0.47]
Total (95% CI)			**92**			**92**	**100.0%**	**0.15 [-0.01, 0.31]**

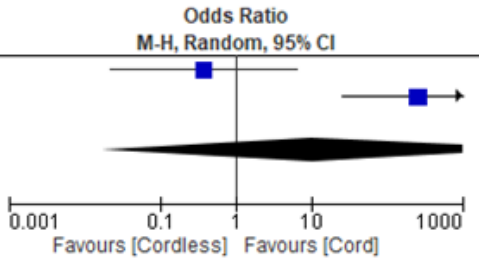
Heterogeneity: Tau² = 0.03; Chi² = 210.76, df = 4 (P < 0.00001); I² = 98%
Test for overall effect: Z = 1.79 (P = 0.07)



V

Study or Subgroup	Cord Events	Cord Total	Cordless Events	Cordless Total	Weight	Odds Ratio M-H, Random, 95% CI
Bennani et al. 2020	1	5	2	5	49.2%	0.38 [0.02, 6.35]
Tiwari et al. 2018	27	30	1	30	50.8%	261.00 [25.57, 2664.03]
Total (95% CI)		**35**		**35**	**100.0%**	**10.42 [0.02, 6415.69]**
Total events	28		3			

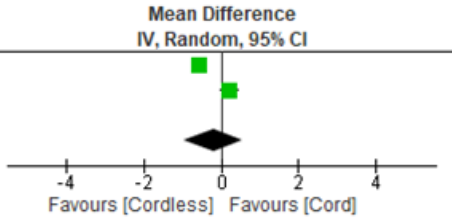
Heterogeneity: Tau² = 19.74; Chi² = 12.32, df = 1 (P = 0.0004); I² = 92%
Test for overall effect: Z = 0.72 (P = 0.47)



X

Study or Subgroup	Cord Mean	Cord SD	Cord Total	Cordless Mean	Cordless SD	Cordless Total	Weight	Mean Difference IV, Random, 95% CI
Beleidy et al. 2020	0.85	0.18	10	1.43	0.24	10	50.2%	-0.58 [-0.77, -0.39]
Gupta et al. 2012	1.066	0.385	20	0.865	0.303	20	49.8%	0.20 [-0.01, 0.42]
Total (95% CI)			**30**			**30**	**100.0%**	**-0.19 [-0.96, 0.57]**

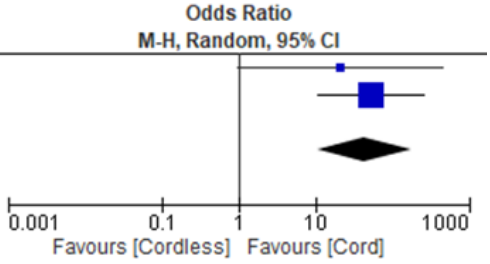
Heterogeneity: Tau² = 0.29; Chi² = 29.04, df = 1 (P < 0.00001); I² = 97%
Test for overall effect: Z = 0.49 (P = 0.62)



Y

Study or Subgroup	Cord Events	Cord Total	Cordless Events	Cordless Total	Weight	Odds Ratio M-H, Random, 95% CI
Beleidy et al. 2020	5	10	0	10	21.2%	21.00 [0.97, 453.91]
Jain et al. 2018	29	39	2	39	78.8%	53.65 [10.90, 264.17]
Total (95% CI)		**49**		**49**	**100.0%**	**43.98 [10.68, 181.04]**
Total events	34		2			

Heterogeneity: Tau² = 0.00; Chi² = 0.28, df = 1 (P = 0.59); I² = 0%
Test for overall effect: Z = 5.24 (P < 0.00001)



(a) Sulcular height, (b) Sulcular width, (c) Bleeding and (d) Gingival recession; Forest plot of the effectiveness of paste in gingival displacement in terms of: (e) Sulcular height, (f) Sulcular width, (g) Bleeding and (h) Gingival recession; Forest plot of the effectiveness of polyvinylsiloxane in gingival displacement in terms of: (i) Sulcular height, (j) Sulcular width and (k) Bleeding; Forest plot of the effectiveness of gel in gingival displacement in terms of: (l) Sulcular height; Forest plot of the effectiveness of paste vs polyvinylsiloxane in gingival displacement in terms of: (m) Sulcular height and (n) Sulcular width; Forest plot of the effectiveness of cordless techniques in gingival displacement in anterior teeth in terms of: (o) Sulcular width; Forest plot of the effectiveness of cordless techniques in gingival displacement in posterior teeth in terms of: (p) Sulcular height, (q) Sulcular width, (r) Bleeding and (s) Gingival recession; Forest plot of the effectiveness of cordless techniques in gingival displacement in anterior and posterior teeth in terms of: (t) Sulcular width; Forest plot of the effectiveness of cordless techniques in gingival displacement in unprepared teeth in terms of: (u) Sulcular width and (v) Bleeding; Forest plot of the effectiveness of cordless techniques in gingival displacement in posterior teeth in terms of: (w) Sulcular height, (x) Sulcular width and (y) Bleeding.

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Table 1. Search strategies for each database.

DATABASE	SEARCH STRATEGY
Pubmed/Medline	((((((((human) OR "gingival tissues") OR "intracrevicular margin") OR teeth) OR tooth) OR incisor) OR canine) OR premolar) OR molar) AND ((((((“astringent retraction paste”) OR “gingival retraction paste”) OR “retraction paste”) OR “chemico mechanical”) OR “gingival paste”) OR cordless) AND ((((“retraction cords”) OR cord) OR mechanical)
Cochrane Library	#1 MeSH descriptor: [Tooth] explode all trees #2 MeSH descriptor: [Incisor] explode all trees #3 MeSH descriptor: [Bicuspid] explode all trees #4 MeSH descriptor: [Molar] explode all trees #5 (human) OR (“gingival tissues”) OR (“intracrevicular margin”) OR (teeth) OR (tooth) OR (incisor) OR (canine) OR (premolar) OR (molar) (Word variations have been searched) #6 #1 OR #2 OR #3 OR #4 OR #5 #7 MeSH descriptor: [Astringents] explode all trees #8 MeSH descriptor: [Gingival retraction techniques] explode all trees #9 (“astringent retraction paste”) OR (“gingival retraction paste”) OR (“retraction paste”) OR (“chemico mechanical”) OR (“gingival paste”) OR (cordless) (Word variations have been searched) #10 #7 OR #8 OR #9 #11 (“retraction cords”) OR (cord) OR (mechanical) (Word variations have been searched) #12 #6 AND #10 AND #11
Scopus	TITLE-ABS-KEY ((((((((human) OR “gingival tissues”) OR “intracrevicular margin”) OR teeth) OR tooth) OR incisor) OR canine) OR premolar) OR molar) AND TITLE-ABS-KEY ((((((“astringent retraction paste”) OR “gingival retraction paste”) OR “retraction paste”) OR “chemico mechanical”) OR “gingival paste”) OR cordless) AND TITLE-ABS-KEY ((((“retraction cords”) OR cord) OR mechanical) AND TITLE-ABS-KEY (“clinical trial”) AND (LIMIT-TO (SUBJAREA, “DENT”)) AND (LIMIT-TO (DOCTYPE, “ar”))
Scielo	((human) OR (“gingival tissues”) OR (“intracrevicular margin”) OR (teeth) OR (tooth)) AND ((“astringent retraction paste”) OR (“gingival retraction paste”) OR (“retraction paste”) OR (“chemico mechanical”) OR (“gingival paste”) OR (cordless)) AND ((“retraction cords”) OR (cord) OR (mechanical)) AND ((“clinical trial”))
Google Scholar	“human” OR “gingival tissues” OR “intracrevicular margin” OR “teeth” OR “tooth” + “astringent retraction paste” OR “gingival retraction paste” OR “retraction paste” OR “chemico mechanical” OR “gingival paste” OR “cordless” + “retraction cords” OR “cord” OR “mechanical” + “clinical trial” –“in vitro” –“systematic review”

Table 2. Reason for exclusion of the studies.

AUTHORS	EXCLUSION REASON
Mehta *et al.*[19]	Non-vital teeth
Thimmappa *et al.*[3]	Vital and non-vital teeth

Table 3. Search strategies for each database.

Author Year	Type of study	Country	Number of patients (M/W)	Mean age (range)	Teeth type	Preparation of teeth	Periodontal status	Groups	Number patients per group	Number of teeth per group	Material brand
Bennani *et al.*[21] 2020	RCT parallel	New Zealand	10	(18 – 25)	Upper premolars	No	Healthy	Cord Paste	5 5	20 20	Knit Trax Cord Expasyl
Qureshi *et al.*[27] 2020	CT crossover	India	10	(18 – 25)	Upper central incisors	No	Healthy	No cord Cord Paste Paste	10 10 10 10	10 10 10 10	N.A Roeko Expasyl 3M
Kavita *et al.*[25] 2020	CT parallel	India	60	(18 – 48)	NR	Yes (total crown)	Healthy	Cord Paste Cord No cord	15 15 15 15	15 15 15 15	NR Expasyl NR N.A
Beleidy *et al.*[20] 2020	RCT parallel	Egypt	40 (4/36)	49.8 (28 – 54)	Premolars	Yes (total crown)	Healthy	Cord Polyviny-lsiloxane Paste Polyviny-lsiloxane	10 10 10 10	10 10 10 10	Knitted, Ultrapak GingiTrac Traxodent No Cord Mega-body Kesari
Kesar *et al.*[26] 2019	CT crossover	India	30	(18 – 22)	Upper incision, canines and premolars	No	Healthy	Cord Cord Cord Gel	30 30 30 30	30 30 30 30	Ultrapak Ultrapak Ultrapak Racegel
Gajbhiye *et al.*[23] 2019	CT crossover	India	10	(25 – 30)	Upper central incisors	No	Healthy	Cord No cord Aquasil	10 10 10	10 10 10	Primecord No Cord Centrix Aquasil printing system
Indriyani *et al.*[24] 2019	CT crossover	Indonesia	32	NR	NR	Yes (total crown)	Healthy	Cord Paste	32 32	64 64	Ultrapak 3M
Jain *et al.*[12] 2018	RCT crossover	India	39	(20 – 50)	Incisors, canines, premolars and molars	Yes (total crown)	Healthy	Cord Paste	39 39	39 39	Ultrapak Expasyl
Tiwari *et al.*[14] 2018	CT crossover	India	30	(19 – 25)	Upper central incisors	No	Healthy	Cord Gel Polyvinyl-siloxane	30 30 30	30 30 30	NR Racegel Magic Foam Cord
Sachdev *et al.*[28] 2018	CT parallel	India	18	(20 – 25)	Mandibular premolars	No	Healthy	Cord Paste Polyvinyl-siloxane	6 6 6	12 12 12	Ultrapak Expasyl Magic Foam Cord
Goutham *et al.*[10] 2018	RCT parallel	India	45	28 (19 – 45)	Upper central incisors	Yes (total crown)	Healthy	Cord Polyvinyl-siloxane Diode laser	15 15 15	15 15 15	NR Magic Foam Cord ------
Chandra *et al.*[22] 2016	RCT parallel	India	40	(20 – 40)	Upper central incisors	No	Healthy	Cord Cord Paste Paste	10 10 10 10	10 10 10 10	Ultrapak SilTrax AS Expasyl Traxodent Hemodent
Prasanna *et al.*[2] 2013	RCT crossover	India	16	NR	Premolars	Yes (total crown)	Healthy	Cord Paste	16 16	16 16	Ultradent Expasyl
Gupta *et al.*[11] 2012	RCT parallel	India	30	(> 18)	NR	Yes	Healthy	Cord Paste Polyvinyl-siloxane	10 10 10	20 20 20	Stay-Put, Roeko Expasyl Magic Foam Cord

NR: Not reported. **CT:** Clinical trial. **RCT:** Randomized clinical trial.

Continued Table 3 ↘

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Continued Table 3 ↘

Author Year	Number of cord / medication	Impression material use	Impression tray type	Plaster type	Measuring instrument	Sulcular height (mm)	Sulcular width (mm)	Bleeding (n)	Gingival recession (mm)
Bennani *et al.*[21]	0 / Aluminum chloride	Polyvinylsiloxane (3M imprint)	Individual	Type IV: GC Fujirock	Digital imaging microscope	- 0.06	0.282	1	NR
	NA				(Model SMZ800, - Nikon)	0.013	0.213	2	NR
Qureshi *et al.*[27]	NA	Monophasic polyether (3M ImpregumTM)	Individual	Type IV: UltraRock	20x stereo-microscope (Wuzhou New Found Instrument)	NR	0.156 ± 0.032	NR	NR
	According to the phenotype/ 25% aluminum sulfate					NR	0.483 ± 0.043	NR	NR
	15% aluminum chloride					NR	0.346 ± 0.086	NR	NR
	Astringent					NR	0.5 ± 0.13	NR	NR
Kavita *et al.*[25]	NR / 15% aluminum chloride	Polyvinylsiloxane	Individual	NR	Optical microscope and image analyzer	NR	0.825 ± 0.034	NR	NR
	15% aluminum chloride					NR	0.482 ± 0.027	NR	NR
						NR	0.742 ± 0.021	NR	NR
						NR	0.214 ± 0.014	NR	NR
Beleidy *et al.*[20]	000 / Saline solution	Monophasic medium consistency (Impregum Penta Soft 3M)	Individual	NR	Stereoscopic microscope (Leica MZ 6) and photo-graphed by a 60x magni-fication attached camera (Leica MC 190 HD)	0.85 ± 0.18	NR	5	NR
	15% ammonium and aluminum sulfate					1.03 ± 0.26	NR	1	NR
	15% aluminum chloride					1.37 ± 0.27	NR	3	NR
	15% ammonium and aluminum sulfate					1.43 ± 0.24	NR	0	NR
Kesari *et al.*[26]	00 / ViscoStat (aluminum chloride)	Monophasic medium body	Individual	Type IV: UltraRock	Stereoscopic microscope (20x)	NR	0.207 ± 0.154	NR	NR
	00 / Vasozine (tetrahydrozoline)					NR	0.216 ± 0.17	NR	NR
	00 / Gel (Racegel)					NR	0.226 ± 0.168	NR	NR
	25% aluminum chloride					NR	0.141 ± 0.108	NR	NR
Gajbhiye *et al.*[23]	NR / 25% aluminum chloride	Polyvinylsiloxane (Aquasil)	Individual	Type IV: UltraRock	Optical microscope and image analysis software	0.299 ± 0.04	0.271 ± 0.02	NR	NR
	15% aluminum chloride					0.231 ± 0.04	0.26 ± 0.02	NR	NR
	25% aluminum chloride					0.195 ± 0.04	0.22 ± 0.02	NR	NR
Indriyani *et al.*[24]	NR / 15.5% ferric sulfate	Polyvinylsiloxane	NR	Type IV Olympus BX43 (50x)	Optical microscope	NR	0.302 ± 0.038	NR	NR
	15% aluminum chloride					NR	0.152 ± 0.023	NR	NR
Jain *et al.*[12]	According to the phenotype/ Saline solution	Polyvinylsiloxane (Aquasil)	Stock bucket	Type IV: UltraRock	Mobile microscope with a minimum count of 0.001 mm (Weswox Optik)	NR	0.407 ± 0.187	29	0.476
	15% aluminum chloride					NR	0.479 ± 0.14	2	0.146
Tiwari *et al.*[14]	According to the phenotype/ aluminum chloride	Polyvinylsiloxane	Individual	Type IV: Kalabhai	Stereoscopic microscope (20x)	NR	0.79 ± 0.14	27	NR
	25% aluminum chloride					NR	0.37 ± 0.06	1	NR
	Aluminum chloride					NR	0.56 ± 0.09	17	NR
Sachdev *et al.*[28]	000	Polyvinylsiloxane	NR	Type IV	Profile projector that has axis (axis X-Y)	0.299 ± 0.04	0.27 ± 0.02	NR	0.124 ± 0.03
	15% aluminum chloride								
	Aluminum chloride								

NR: Not reported. **CT:** Clinical trial. **RCT:** Randomized clinical trial.

Continued Table 3 ↘

Author Year	Number of cord / medication	Impression material use	Impression tray type	Plaster type	Measuring instrument	Sulcular height (mm)	Sulcular width (mm)	Bleeding (n)	Gingival recession (mm)
Goutham *et al.* [10]	According to the phenotype / 15% aluminum chloride	Polyvinylsiloxane	NR	Type IV	Optical microscope attached to Axiovision (soft imaging system software AC)	NR	0.44 ± 0.112	NR	NR
	NR					NR	0.313 ± 0.092	NR	NR
	NA					NR	0.48 ± 0.101	NR	NR
Chandra *et al.* [22]	0 / Epinephrine	NR	NR	NR	Still camera (model D-300S with 60mm lens and ring flash; Nikon Corp)	NR	0.25 ± 0.143	0	NR
	0 / Aluminum sulfate					NR	0.256 ± 0.081	0	NR
	15% aluminum chloride					NR	0.104 ± 0.038	0	NR
	15% aluminum chloride					NR	0.168 ± 0.126	0	NR
Prasanna *et al.* [2]	00 / 15.5% ferric sulfate	Polyvinyl-siloxane (3M ESPE, Express STD)	Individual	NR	Optical stereoscopic microscope (Olympus)	NR	0.21 ± 0.01	NR	NR
	15% aluminum chloride					NR	0.26 ± 0.02	NR	NR
Gupta *et al.* [11]	According to the phenotype	Polyether (Impregnum Soft, 3M)	Individual	NR	Stereoscopic microsco-pe and image analysis software (Image-Pro Express; Media Cyber-netics, Silver Spring)	1.066 ± 0.385	0.233 ± 0.082	NR	NR
	15% aluminum chloride					0.484 ± 0.195	0.151 ± 0.069	NR	NR
	Aluminum chloride					0.865 ± 0.303	0.199 ± .085	NR	NR
Kazemi *et al.* [13]	0 / 15% aluminum chloride	Polyvinylsi-loxane (Speedex, Coltenez	Individual	Type IV: GC Fujirock	Mobile microscope (Edmund optics Inc.)	NR	0.46 ± 0.03	NR	0.14 ± 0.07
	15% aluminum chloride					NR	0.34 ± 0.04	NR	0.03 ± 0.05

Table 4. GRADE analysis

CERTAINTY ASSESSMENT							CERTAINTY
NUMBER OF STUDIES	STUDY DESIGN	RISK OF BIAS	INCONSISTENCY	INDIRECTNESS	IMPRECISION	OTHER CONSIDE-RATIONS	
14	CT	serious	very serious	not serious	not serious	serious	Very low ⨁◯◯◯
Effectiveness of cordless techniques in gingival displacement							

- Gel *versus* traditional technique

The effectiveness of gel as a cordless technique on gingival displacement in terms of sulcular height was determined in two[14,26] studies, showing that there was no statistically significant difference (p= 0.13, I^2 = 98%, MD = 0.25 [-0.07 – 0.58]) (Figure 3).

- Paste *versus* Polyvinylsiloxane technique

The effectiveness of paste *versus* polyviny-lsiloxane as a cordless technique on gingival displacement in terms of sulcular height and sulcular width; was determined in three[11,20,28] and two[11,28] studies, showing that there was a statistically significant difference for sulcular

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width (p< 0.00001, I^2 = 0%, MD = -0.04 [-0.06 – -0.03])); and there was no statistically significant dif-ference for sulcular height (p= 0.18, I^2= 89%, MD = -0.16 [-0.39 – 0.07]), (Figure 3).

- Cord *versus* Cordless technique in anterior teeth

The effectiveness of cordless techniques in gingival displacement in anterior teeth in terms of sulcular width was determined in four[10,14,22,27] studies, showing that there was a statistically significant difference (p< 0.00001, I^2= 67%, MD = 0.15 [0.09 – 0.21]), (Figure 3).

- Cord *versus* Cordless technique in posterior teeth

The effectiveness of cordless techniques in gingival displacement in posterior teeth in terms of sulcular height, sulcular width, bleeding, and gingival recession; was determined in two,[20,28] three,[2,13,28] two[20,21] and two[13,28] studies, showing that there was a statistically significant difference for gingival recession (p= 0.03, I^2= 80%, MD = 0.07 [0.01 – 0.14]); and there was no statistically significant difference for sulcular height (p= 0.52, I^2 = 97%, MD = -0.2 [-0.81 – 0.41]), sulcular width (p = 0.41, I^2 = 99%, MD = 0.04 [-0.05 – 0.13]) and bleeding (p= 0.76, I^2 = 12%, MD = 1.3 [0.24 – 6.82]), (Figure 3).

- Cord *verus* Cordless technique in anterior and posterior teeth

The effectiveness of cordless techniques in gingival displacement in anterior and posterior teeth in terms of sulcular width was determined in two[12,26] studies, showing that there was no statistically significant difference (p=0.93, I^2= 89%, MD = 0.01 [-0.15 – 0.16]) (Figure 3).

- Cord *versus* Cordless technique in unprepared teeth:

The effectiveness of cordless techniques in gingival displacement in unprepared teeth in terms of sulcular width and bleeding; was determined in five[14,22,26–28] and two[14,21] studies, showing that there was no a statistically significant difference for sulcular width (p = 0.07, I^2 = 98%, MD = 0.15 [-0.01 – 0.31]); and bleeding (p = 0.47, I^2 = 92%, MD = 10.42 [0.02 – 6415.69]) (Figure 3).

- Cord *versus* Cordless technique in teeth with preparation:

The effectiveness of cordless techniques in gingival displacement in teeth with preparation in terms of sulcular height, sulcular width and bleeding; was determined in two,[11,20] seven[2,10–13,24,25] and two[12,20] studies, showing that there was a statistically significant difference for bleeding (p<0.00001, I^2 = 0%, MD = 43.98 [10.68 – 181.04]); and there was no statistically significant difference for sulcular height (p= 0.62, I^2 = 97%, MD = -0.19 [-0.96 – 0.57]) and sulcular width (p= 0.11, I^2 = 100%, MD = 0.09 [-0.02 – 0.21]) (Figure 3).

GRADE analysis

When evaluating the included studies, it was observed that there is very low certainty in the effectiveness of cordless techniques in gingival displacement (Table 4).

DISCUSSION

The present systematic review and meta-analysis was based on human clinical trials of parallel and crossover design investigating the effectiveness of cordless techniques in

gingival displacement. This differs from the reviews by Martins *et al.*,[5] where only the gingival width is evaluated in the dental stone and in the impression material with different measurement techniques.

And to Huang *et al.*,[6] where only one review without meta-analysis was carried out. Gingival displacement is a procedure that aims to give access to the impression material to the gingival-sulcus/crevice; it can be achieved with a minimum opening of 0.2 mm. [27.]

This procedure can guarantee the exact copy of the finishing line of the prepared tooth either with impression material or scanner. In addition, it will provide an adequate thickness of the impression material to resist distortion or tearing.[5] Therefore, gingival displacement is one of the most challenging aspects of fixed prosthesis treatment at the time of taking an impression of a prepared tooth.[21]

In this review, all studies with the conventional cord technique reported a gingival sulcus width greater than 0.2 mm, which is why it is still considered the gold standard technique. Only two studies[22,26] with cordless techniques with polyvinylsiloxane reported a width of less than 0.2 mm. The conventional cord technique yielded the greatest width of the gingival sulcus, results similar to two studies, followed by the wireless paste and polyvinylsiloxane techniques, respectively.[5,6]

This can be attributed to the mechanical action of placing the cord within the sulcus/crevice[20], which does not happen with cordless techniques that target directly on gingiva around the tooth. However, the effectiveness of the cordless technique with paste depends on the hygroscopic expansion of kaolin being a constituent of the paste. This substance when exposed in contact with the crevicular fluid provides a smooth displacement of the gingiva.[28]

In the present meta-analysis, a greater gingival recession was observed in the conventional cord technique compared to the cordless technique with paste. This can be generated by the pressure exerted during the cord introduction into the gingival sulcus, which can cause immediate bleeding and subsequently gingival recession. Interestingly, the gingival sulcus can withstand pressures lower than 2400 KPa without trauma. However, the pressure exerted for the placement of cords can reach up to 5000 KPa, producing irreversible damage.[21]

In addition, the location of the finishing line of the marginal preparation should be taken into account in order to prevent tissue damage.

The greater gingival trauma, the greater the gingival recession.[12] Regarding bleeding from gingiva before traditional impression, no significant differences were observed between the conventional technique and the cordless technique with paste.

The cords used in these studies,[10,12,14,20,21,24–28] with the exception of Gupta *et al.*,[11] and Sachdev *et al.*,[28] who used dry cords and those of Beleidy *et al.*,[20] and Jain *et al.*,[12] who used saline solution; were impregnated with astringent (aluminum chloride, aluminum sulfate, ferric sulfate, tetrahydrozoline).

Astringent's metallic salts cause gingival displacement by protein precipitation and

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inhibition of the transcapillary movement of plasma proteins, thus re-ducing cell permeability and subsequently bleeding.[27] Likewise, 15% aluminum chloride is a component of pastes such as Expansyl and Traxodent used in cordless techniques.

However, a significant difference is observed between the conventional technique and the wireless technique with polyvinylsiloxane such as Magic Foam Cord and Gingi Trac. These are gingival displacement systems based on an expansion silicone, which is applied around the margin of the prepared tooth under controlled pressure exerted with a compression cap. Therefore, by not applying direct pressure within the gingival sulcus, it causes less trauma and less bleeding.[6,8]

Regarding the sulcular height, no significant differences were observed between the conventional and the cordless technique with paste or with polyvinylsiloxane, not even in teeth with preparation.[14]

The strengths of this systematic review and meta-analysis are that a rigorous search for information was carried out, in accordance with the guidelines of the PRISMA guide, the inclusion clinical trials only in humans, and the implementation of GRADE analysis to assess the feasibility of generalization of the outcomes of the included studies.

However, there were certain limitations such as considerable heterogeneity between the included studies regarding the use of various methods to measure the width of the sulcus, in addition to measuring anterior and posterior teeth, unprepared and prepared teeth, and different types of dental materials. For all the above, the authors recommend a cautious interpretation of the results; which justifies the need for future long-term ran-domized controlled clinical trials with an ade-quate standard methodology.

CONCLUSION

According to the findings of the present review, the conventional technique resulted in better gingival displacement (width) than the cordless techniques. However, cordless techniques regardless of tooth type and preparation are less damaging to soft tissues.

These results cannot be cannot be considered as conclusive due to high heterogeneity of the included studies and very low strength of clinical practice recommendations presented in the included studies.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interest in relation to the published results.

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AUTHORS' CONTRIBUTIONS

Fredy Cruzado-Oliva: Planned the protocol for the systematic review, conducted the databases search, supervised the progress made, drafted the manuscript and revised the final manuscript.

Heber Arbildo-Vega: Search in databases, selected articles and revised the final manuscript.

Edward Infantes-Ruíz: Data extraction from the selected articles, collected the data, assessment of risk of bias of included studies and revised the final manuscript.

Jhonatan Rodríguez-Angulo: Extracted the data from the selected articles, collected the data, assessed the risk of bias of included studies and revised the final manuscript.

Luis Alarco-La Rosa: Resolution of any discrepancy between the authors who evaluated the included studies, and revised the final manuscript.

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