Received: 16 February 2023 | Revised: 29 April 2023 | Accepted: 27 June 2023
DOI: 10.1111/jerd.13102

REVIEW ARTICLE

WILEY

Is surface roughness of direct resin composite restorations material and polisher-dependent? A systematic review

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Abstract

Statement of Problem: Direct resin composite bonding offers a highly esthetic, minimally invasive option for the treatment of anterior teeth however the challenge to improve their longevity remains. Direct resin composite restorations are limited by the risk of staining which may be influenced by the final surface roughness (Ra) of composite achieved.

Purpose: The purpose of this review is to investigate, using a systematic approach, whether the final surface roughness of anterior composite restorations is affected by the interaction between resin composite and polishing systems.

Materials and Methods: The review was conducted by 3 independent reviewers and included articles published up to January 21, 2021. Three electronic databases were searched: Medline, Embase, and Web of Science. Studies assessing a quantitative effect of polishing methods on the Ra of direct composite resin materials published after the year 2000 and restricted to the English language were included.

Results: The database search for the effect of polishing systems on composite materials retrieved 125 eligible studies. Twelve duplicate records were removed. The resulting records were screened using title and abstract leading to 38 reports which were sought for retrieval. Application of eligibility criteria led to 11 studies included in the review. Hand searching of these studies yielded no additional papers.

Conclusions: There is insufficient evidence to determine whether combination of composite and polisher influences final Ra. More research is required to determine if there is an optimum combination of polisher and composite.

Clinical Implications: Polishing should be completed following planned finishing procedures. The approximation to the final surface and which finishing burs to use, if any, should be considered when planning a restoration. Durafill VS predictably achieves an acceptable Ra by different polishers.

KEYWORDS
composite, finishing, polishing, profilometer, surface roughness

Achieving an optimal surface roughness of direct resin composite restorations. Is the outcome dependent on resin composite/polisher combination? A systematic review.

1 | INTRODUCTION

The advantages of direct resin composite bonding are well known. Capable of delivering excellent esthetics using minimally invasive techniques,[1,2] they are an increasingly popular option with clinicians and patients to improve anterior esthetics.

Success of anterior composite restorations is limited by risk of staining, discoloration and fracture.[3] A systematic review found survival rates of anterior composite restorations between 53.4% and 100% over 3 to 17 years.[4] The discrepancy in reported survival rates are attributed to many factors including the patients' diet,[1] tooth-brushing regime,[5] type of composite used,[6] method of application,[7,8] surface roughness (Ra)[9] and operator skill. This can lead to uncertainty when deciding how to optimally restore using composite.[6]

The surface roughness (Ra) of composite restorations is considered an important factor in determining risk of failure.[10] Ra is assessed quantitatively through profilometry and qualitatively through scanning electron microscopy (SEM).[11] A review by Bollen et al.[9]into the optimal Ra of dental materials set a quantitative threshold value of 0.2 μm. An Ra above 0.2 μm is proposed to increase risk of bacterial accumulation whilst achieving lower than this is thought to have no effect.[9] It has been demonstrated that as Ra increases, so does the risk of composite discoloration.[10] An Ra of 0.2 μm is therefore considered to be a threshold outcome after polishing composite restorations.[9]

Ra may be influenced by both composite composition and polishing procedures. The "pitfalls" of early macro-filled composites are well described but with developments in micro and nano-filler technology, questions remain as to whether this is still a cause for concern clinically.[12] Achievable smoothness drives the development of composite materials resulting in a variety of composite materials on the market[5,13] with each material boasting superior surface finish capabilities according to the filler size and content. The lowest capable Ra of a material is unlikely to be clinically achievable since laboratory conditions cannot account for all the variables encountered clinically.

It is accepted that the smoothest surface possible is achieved via curing under mylar strips.[14] This however results in the formation of a resin rich layer[11] with a lower microhardness value[14] and it is unlikely that the final shape of the restoration will be achieved through use of mylar strip alone.[15] Commonly, finishing is required to achieve desired contours which introduces surface roughness.[14] Polishing is then undertaken to reduce this roughness.[14] Polishing systems differ in their mechanisms; systems utilize a series of progressively fine sandpaper discs containing an abrasive element such as aluminum oxide particles or polishers with an abrasive element, that is, diamond particles, dispersed within silicon rubber and polishing pastes.[5,14,15]

Deciding which material and polishing system to use is not straightforward as it may be that one factor influences the other. A systematic review by Kaizer et al.[6] compared the Ra of nanofill and submicron composites to microhybrid composite and found insufficient evidence to support one type over another but suggested that the final surface properties of composite may be more dependent on the combination of restorative material and finishing system used.

The aim of this review is to investigate whether the final surface roughness of anterior composite restorations is affected by the interaction between resin composite and polishing systems. Objectives of this review are using a systematic approach, to:

- identify what combinations of resin composite and polishing systems achieve an Ra of <0.2 μm
- evaluate whether specific combinations of resin composite and polishing systems achieve better outcomes than others
- evaluate other factors that influence Ra value, for example, finishing procedure
- evaluate the quality of the evidence base and make recommendations for future research.

It is hypothesized that a clinically acceptable Ra will be produced regardless of combination of composite and polisher. At the time of writing, no such reviews are proposed or exist.

2 | MATERIALS AND METHODS

This review was conducted using guidelines from the Cochrane handbook for systematic reviews of interventions[16] and follows PRISMA guidelines (Table 1). The eligibility criteria used are shown in Table 2.

Electronic searches for identification of studies were based on the eligibility criteria. A structured search strategy of MEDLINE, EMBASE and ISI Web of science was conducted using key words and MeSH terms between 2000 and January 21, 2021 (Table 3).

To ensure no reviews of this type were proposed or conducted at the time of the search the International Prospective Register of Systematic Reviews: PROSPERO (https://www.crd.york.ac.uk/PROSPERO/) was searched with the search term "composite resin" to October 12, 2020.

Articles were cross-checked and duplicates removed. Author SD independently screened the resulting abstracts according to the inclusion and exclusion criteria in Table 4. Studies which appeared to meet the criteria and those where it was not possible to ascertain eligibility from the abstract were selected for full-text reading online or via article reach and assessed. The references of papers identified were hand searched for additional relevant papers.

Data were extracted from the included studies independently by author SD and checked for accuracy by author KM. This was recorded in a specially designed data extraction table. This included information listed in Table 5. When it was not possible to view the data or it was unclear within the study the corresponding author was contacted via email. When no response was received, the study was excluded.

Author SD independently assessed risk of bias using the OHAT Risk of Bias Rating Tool for Human and Animal Studies,[18] which was subsequently checked by author LH. The OHAT tool comprises 11 items to evaluate threats to internal validity of studies and is applicable across human and non-human animal studies, with adapted criteria for experimental animal studies suitable for in vitro studies (Rooney, 2015). Additional questions were added that were relevant

TABLE 1 Prisma checklist.

Section and topic	Item #	Checklist item	Location where item is reported
Title			
Title	1	Identify the report as a systematic review.	2
Abstract			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	2,3
Introduction			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	4
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	5
Methods			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	6
Information sources	6	Specify all databases, registers, websites, organizations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	6
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	6
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	6
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	6
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	7
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	8
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	7
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	8
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	?
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	7
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	6
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	7
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	N/A
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	N/A

(Continues)

TABLE 1 (Continued)

Section and topic	Item #	Checklist item	Location where item is reported
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	N/A
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	N/A
Results			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	8
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	8
Study characteristics	17	Cite each included study and present its characteristics.	8,30
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	7,32
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	N/A
Results of syntheses	20a	For each synthesis, briefly summarize the characteristics and risk of bias among contributing studies.	7,32
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/ credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	9 to 16
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	16
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	N/A
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	N/A
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	N/A
Discussion			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	16–21
	23b	Discuss any limitations of the evidence included in the review.	21
	23c	Discuss any limitations of the review processes used.	21, 22
	23d	Discuss implications of the results for practice, policy, and future research.	22
Other information			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	Not registered
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	Appendix
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	n/a
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	No funders or sponsors
Competing interests	26	Declare any competing interests of review authors.	No competing interests
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	Appendix

Abbreviation: N/A, not applicable.

TABLE 2 Eligibility Criteria.

Types of studies	Randomized controlled trials (RCTs) and controlled trials were considered for this review. Whilst RCTs are recognized as the gold-standard of evidence, in the absence of sufficient numbers of RCTs a summary of evidence from non-randomized evaluations can provide essential information to guide future trials.[17]
Types of participants	Composite materials used in the treatment of anterior restorations.
Types of interventions	Composite polishing systems
Primary outcome measure	Surface roughness (Ra) following polishing procedure assessed against a threshold value of 0.2 mm.
Secondary outcome measure	Variables which may influence the primary outcome measure

to potential biases associated with investigations of the type reviewed in this paper: given the proprietary/commercial nature of the interventions being compared, 'Were potential conflicts of interest declared?'

Study populations and interventions were assessed for heterogeneity to determine whether meta-analysis or detailed narrative synthesis was indicated. If heterogenous, any trends or patterns on the most popular polishers against compositions of composite would be reported on with regards to Ra and compared to the threshold value of 0.2 μm. The potential reasons for any trends found would also be reported on. Due to variations in methodologies and heterogeneity amongst composites and polishers it was not possible to perform a meta-analysis, therefore a narrative synthesis is presented.

3 | RESULTS

The search resulted in 125 papers (Figure 1). Screening and removal of duplicates resulted in 38 papers. Twenty-four reports were excluded based on low sample number. Three reports were excluded due to lack of data presented. The authors of these papers were contacted for the results by email but failed to respond. Eleven papers were identified (Table 6) as suitable for inclusion and data extraction. No further papers were identified through hand searching.

Of the 11 papers identified, profilometric assessment of final Ra achieved was extracted. In the two studies; Daud et al.[11] and Berger et al.,[19] which used SEM, these were used to confirm findings of profilometric measurements and not independently reviewed therefore these measurements were not extracted. Data regarding composite systems not used in anterior teeth such as packable composite resins tested in the study by Barbosa et al.[20] was not extracted neither was data regarding the effects of color change from Sarac et al.[21] as they did not meet the scope of this review.

Characteristics of included studies are shown in Table 6. Ten studies,[12,19–27] were controlled trials, level 3 in the hierarchy of

TABLE 3 Search strategies: Medline, Embase and Web of Science.

Set	Search statement	
1.	Exp dental restoration, permanent/ or exp composite resins/ or dental restoration.mp.	
2.	Dental polishing.mp. Or exp dental polishing/	
3.	Finishing.mp.	
4.	2 or 3	
5.	1 and 4	
6.	Surface properties.mp. Or exp Surface Properties/	
7.	Smoothness.mp.	
8.	Staining.mp.	
9.	6 or 7 or 8	
10.	5 and 9	
11.	Limit 10 to English language	
Set	**Results**	
# 11	149	#10 AND #5 Indexes = SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Timespan = All years
# 10	11,94,566	#9 OR #8 OR #7 Indexes = SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Timespan = All years
# 9	3,88,393	class = "history-span" > TOPIC: class = "history-span" > (staining) Indexes = SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Timespan = All years
# 8	29,223	class = "history-span" > TOPIC: class = "history-span" > (smoothness) Indexes = SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Timespan = All years
# 7	7,82,793	class = "history-span" > TOPIC: class = "history-span" > (surface properties) Indexes = SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Timespan = All years
# 6	25,644	class = "history-span" > TOPIC: class = "history-span" > (surface finish) Indexes = SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Timespan = All years
# 5	728	#4 AND #1 Indexes = SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Timespan = All years
# 4	1,02,105	#3 OR #2 Indexes = SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Timespan = All years
# 3	1,00,105	class = "history-span" > TOPIC: class = "history-span" > (finishing)

(Continues)

TABLE 3 (Continued)

Set	Results	
		Indexes = SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Timespan = All years
# 2	2252	class = "history-span" > TOPIC: class = "history-span" > (dental polishing) Indexes = SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Timespan = All years
# 1	14,454	class = "history-span" > TOPIC: class = "history-span" > (dental restoration) Indexes = SCI-EXPANDED, SSCI, A&HCI, CPCI-S, CPCI-SSH, ESCI Timespan = All years

TABLE 4 Inclusion / exclusion criteria.

Inclusion criteria	Studies restricted to the English language.
	Studies which assessed direct composite restorative materials.
	Trials conducted after the year 2000; a reflection of the composite materials in use today.
Exclusion criteria	Studies which compared materials not used in anterior restorations, that is, flowable, packable and bulk fill composites. Many composite materials are suitable both anteriorly and posteriorly, but some are exclusively designed for posterior teeth.
	Methods which introduced confounding variables such as artificial aging and indirect restorations
	Sample sizes less than eight were excluded in order to increase the reliability of the results

TABLE 5 Information to be extracted.

Trial methods	Methods of Ra measurement
	Delayed or immediate finishing
Participants	Sample sizes
	Composite composition
Intervention	Polishing system used
Outcomes	Primary outcomes as specified. Profilometric assessment of final Ra achieved. Initial Ra will not be recorded since the area of interest for this study is the Ra after polishing rather than net improvement.
	Secondary outcomes as specified

evidence.[28] Daud et al.[11] conducted an RCT which would normally rank as level 4,[28] however, due to lack of blinding and randomization of all aspects, it has been ranked as evidence level 3 and considered a controlled trial instead.[29] Due to the lack of RCTs, it was not possible to assess for publication bias via a funnel plot.

Table 7 presents an overview of polishing systems tested against different composite compositions. Composites were grouped according to their composition. Sof-Lex discs, Super-Snap and Enhance/PoGo were the most tested polishing systems.

Studies were overall of moderate quality with likely high risk of bias associated with lack of blinding of investigators to the intervention and the outcomes, as well as inconsistent approaches to randomization (Table 8). Due to the in vitro nature of the studies, reporting of control of experimental conditions and application of interventions was generally good, although the use of a single operator was noted across most studies. While no conflicts of interest were identified, in several studies no conflicts of interest statement were included.

Primary outcomes of final Ra after polishing and key study findings are shown in Table 9. Not all combinations of polisher and composite produced an Ra of less than 0.2 mm and outcomes were inconsistent for polishers used in different studies.

Of 131 combinations, 77 produced Ra of less than 0.2 mm. When standard deviation is included 43 combinations of polisher and composite achieved an Ra less than 0.2 mm. No data trends were noted.

To aid observation, we plotted Ra, material type and polishing system for the most frequently tested polishing systems: Sof-Lex, Super-Snap and Enhance/PoGo (Figure 2-4). Due to the heterogeneity between studies, which limited direct comparison between composite compositions, results were grouped according to paper.

Five papers[11,19,20,22,26] tested the Sof-Lex system. Outcomes are shown in Figure 2.

Two studies[19,22] achieved a mean Ra of below 0.2 mm for all categories of composites polished with Sof-Lex discs. Two studies[11,20] observed no significant difference between composite materials when polished with Sof-Lex discs but a statistically significant higher Ra ($P < 0.0001$ and $P < 0.05$, respectively) was found when Sof-Lex discs were used following diamond burs compared to tungsten carbide burs. Two studies[21,26] reported Ra above 0.2 mm for all composites tested. The most tested composite against Sof-Lex disc was Filtek Z250. Two studies[11,20] observed Ra of under or close to threshold value whereas[21,26] observed Ra exceeding the threshold value by over 50%. Across all studies which tested Sof-Lex disc, no clear relationship between Ra and composite composition is observed but finishing procedure is highlighted as a possible cause of higher than threshold Ra.

Four papers[11,19,22,26] assessed the outcome of polishing with the Enhance/PoGo system (Figure 3)

One study[19] observed a clinically favorable outcome for all types of composite tested in combination with Enhance/PoGo. Another study[22] only achieved a clinically acceptable Ra with Enhance/PoGo when used with microfilled Durafill VS. Daud et al.[11] observed no difference according to composite composition but an Ra greater than 0.2 μm when 20 μm grit diamond burs were used. One study[26] observed higher than threshold outcomes across all composites tested.

Enhance/PoGo do not perform equally well across all composites. Composite composition and finishing procedure are shown to influence Ra.

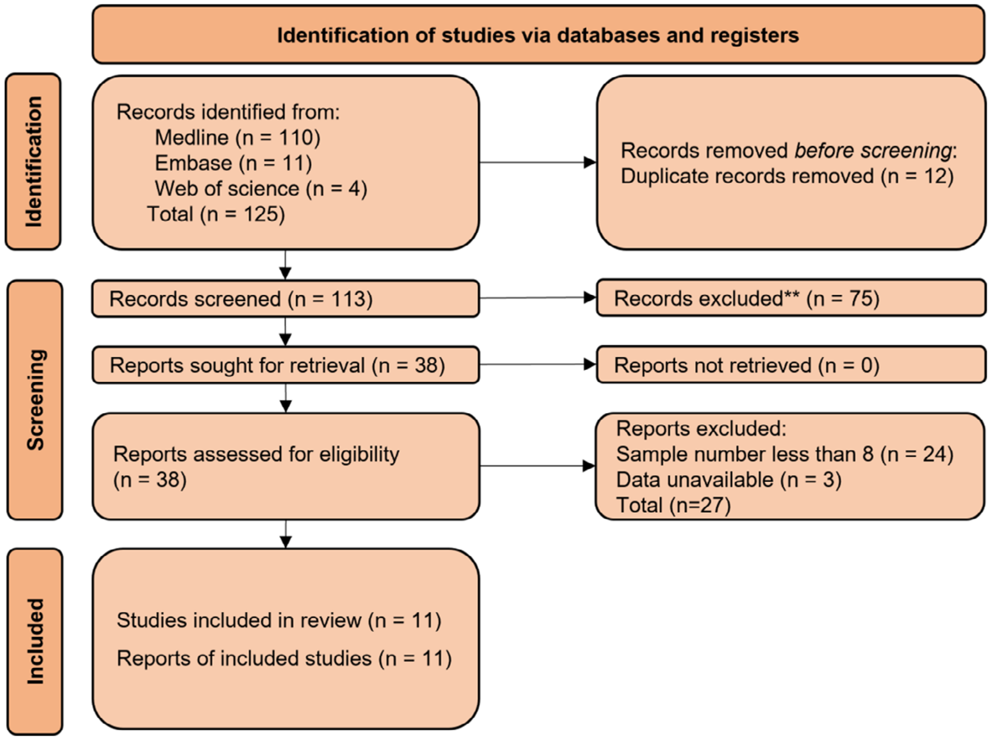

FIGURE 1 PRISMA flow diagram.

Three papers[20,22,25] assessed the outcome of Super-Snap discs (see Figure 4). All composite combinations tested, except microhybrid Filtek Z250,[20] scored mean Ra below 0.2 mm when using Super-Snap discs. There may be an error in the values presented by Baseren[25] as the standard deviation would imply an impossible, negative, Ra. This data highlights microhybrid composite composition as an influencing factor for increasing Ra. Finishing protocol did not affect the Ra in this limited data set.

Secondary Outcomes included influence of finishing procedure. To verify a relationship regarding the influence of finishing protocol on Ra, groupings were plotted according to the finishing procedure (Figures 5–7)

Sof-Lex polishing preceded by no finishing procedure, tungsten carbide burs and medium-grit Sof-Lex disc resulted in mean Ra below threshold value regardless of composite composition. A trend toward increasing to above threshold Ra when silicon carbide paper is used to simulate finishing and mixed results for finishing with diamond burs is observed (Figure 5). The Enhance/PoGo system produced below threshold Ra when preceded by no finishing procedure or tungsten carbide bur. Increases in Ra to above threshold are observed when finishing with medium-grit Sof-Lex disc and either fine or extra-fine diamond burs. (Figure 6) When polishing with Super-Snap discs, no obvious influence of finishing procedure on Ra is observed (Figure 7).

The influence of other variables were also recorded as secondary outcomes. One study[22] finished immediately and this did not noticeably influence outcome. Three studies[12,22,23] identified operator skill as a possible influence. One study[25] highlighted the importance of the shape of the polishing surface and another[12] noted the influence of the tooth-composite interface with aluminum oxide disc performing well on the composite surface and composite/enamel interface and silicon polishers and brushes impregnated with silicon carbide performing better at the composite/cementum interface. The most tested polishers are all multi-step systems. One study[22] noted a larger percentage of multi-step systems achieving below 0.2 μm when compared to single-step polishers, however this was not conclusive.

4 | DISCUSSION

This novel review aimed to assess polishing system or method against composite composition as a single factor in the outcome of Ra. Due to the wide variety in combinations of composite and polishing systems analyzed in the included studies, it is not possible to draw a clear conclusion on this relationship. However, insights into consideration of finishing/polishing protocol and choice of material have been revealed through this analysis.

The ability of polishers to achieve an Ra below 0.2 μm is likely to be overestimated by these studies. Study outcomes were achieved under the best possible, laboratory, conditions and cannot account for all the variables encountered clinically. Additionally, profilometric measurements are thought to underestimate Ra of dental composites.[30]

There is insufficient evidence to confirm or reject a relationship between composite composition and efficacy of polishing systems. Results from the selected papers show conflicting evidence. St Pierre

TABLE 6 Included studies.

Study	Study design	Sample size	Method of surface roughness analysis	Polishing systems tested	Composite materials tested	Timing of finishing	Composite shape	Finishing protocol
Daud et al.[11]	Randomized controlled trial (in-vitro)	10	3-D optical profilometer (ProScan- 2000; Scantron Industrial Products Ltd., Taunton, UK) and SEM	PoGo, Sof-Lex discs	Filtek Supreme XTE, Filtek Z250	Delayed	Flat cylinder	Finishing with diamond bur/tungsten carbide bur prior to polishing
Babina et al.[12]	Controlled trial (in-vitro)	14	Surface roughness tester (Surftest SJ-401, Mitutoyo, Kanagawa, Japan)	Optidisc, Opti1step and optiShine, Opti1step and superPolish	Premise, Herculite Ultra, Harmonize	Delayed	Filled class V cavity cut in extracted natural tooth	Finishing with diamond bur/tungsten carbide bur prior to polishing
Berger et al.[19]	Controlled trial (in-vitro)	10	Profilometer (Surfcorder SE 1700, Kosaka Corp., Tokyo, Japan) and SEM	Sof-Lex discs, Enhance/PoGo, Flexi- discs and enamelize	Filtek Supreme Plus, Esthet-X, Renamel Microfill	Delayed	Flat cylinder	No finishing
Barbosa et al.[20]	Controlled trial (in-vitro)	10	Surface profilometer (Homme Tester T 1000, Hommelwerke, Germany)	Sof-Lex discs, Super- snap discs, Rubber points and felt polishing disc	Durafill, Perfection, Filtek Z250	Delayed	Flat cylinder	No finishing and finishing with diamond bur/tungsten carbide bur prior to polishing
Sarac et al.[21]	Controlled trial (in-vitro)	10	Surface roughness tester (Surftest 402, Mitutoyo, Kanagawa, Japan)	Sof-Lex discs, Astropol	Grandio, Filtek Z250, Quadrant universal LC	Delayed	Flat cylinder	Finished with silicon carbide abrasive paper
St-Pierre et al.[22]	Controlled trial (in-vitro)	8	Surface roughness tester (Surftest 402, Mitutoyo, Kanagawa, Japan)	Astropol, HiLuster Plus, D-Fine, Diacomp, ET Illustra, Sof-Lex wheels, Sof-Lex discs, Super-snap, Enhance/PoGo, Optrapol, One gloss, ComposiPro brush	Durafill Vs, Filtek Supreme Ultra, Grandio SO, Venus Pearl	Immediate	Convex mold	Finishing with medium-grit polisher prior to polishing
Al Jazairy et al.[23]	Controlled trial (in-vitro)	20	Surface profilometer (Talysurf Intra, AMETEK Inc, Pennsylvania, USA)	PoGo, Optrapol	I PS Empress Direct, Filtek P90	Delayed	Flat cylinder	Finished with silicon carbide abrasive paper
Avsar et al.[24]	Controlled trial (in-vitro)	8	Surface roughness tester (Surftest 402, Mitutoyo, Kanagawa, Japan)	Sof-Lex discs, Silicone rubber	Grandio, Ice, Smile, Aelite enamel, Premise, Filtek Supreme XT	Delayed	Flat cylinder	Finishing with diamond bur/tungsten carbide bur prior to polishing

TABLE 6 (Continued)

Study	Study design	Sample size	Method of surface roughness analysis	Polishing systems tested	Composite materials tested	Timing of finishing	Composite shape	Finishing protocol
Başeren[25]	Controlled trial (in-vitro)	10	Profilometer (Mahr Perthometer S4P, Mahr Inc., Providence, USA)	Super-snap, Astropol/Astrobrush	Filtek Supreme, Grandio	Delayed	Flat cylinder	Finishing with diamond bur/tungsten carbide bur prior to polishing
Scheibe et al.[26]	Controlled trial (in-vitro)	9	Mechanical roughness tester (Surftest 301, Mitutoyo America Corporation, Suzano, SP, Brazil)	Enhance/PoGo, Felt disc and diamond paste, Sof-Lex discs	Charisma, Fill Magic, TPH Spectrum, Filtek Z100, Filtek Z250	Delayed	Flat cylinder	Finishing with diamond bur/tungsten carbide bur prior to polishing
Santos et al.[27]	Controlled trial (in-vitro)	10	Surface profilometer (Mitutoyo SJ-210 Surftest, Mitutoyo America)	Tungsten carbide bur, D-fine, Flame point prepolisher and shine	Tetric Evo-ceram, Filtek Supreme Ultra	Delayed	Flat cylinder	Finishing with diamond bur/tungsten carbide bur prior to polishing

et al.[22] observed a statistically and clinically significant ($P < 0.0001$) interaction between polishing systems and composite composition. Not all polishing systems performed equally well on different composites. In contrast AlJazairy et al.[23] and Berger et al.[19] did not report a clinically relevant difference in outcome between combinations of composite and polishers tested. Daud et al.[11] and Santos et al.[27] found no evidence that polishers performed differently according to composite type. Some systems performed differently with the same category of composition of composite and finishing procedure; with different outcomes according to study e.g. Sof-Lex discs with microhybrid composite (Figure 2). Composite materials vary in their composition not only with regard to filler size and homogeneity,[6] on the basis of which they are classified, but also due to their filler matrix and how the filler particles are bound and dispersed within the matrix.[31] This could explain why some polishers perform differently with different composites despite their being classified as the same composition.

Whilst efficacy of polishers may or may not be affected by composite composition, not all polishers are equally efficient, with some polishers failing consistently to achieve below threshold Ra. Babina et al.[12] observed a significant effect of polishing method ($p < 0.001$) with Optidisc outperforming Opti1step and Baseren[25] observed Ra increasing to above 0.2 μm when Astropol polishers were used compared to Super-Snap however this result was not statistically significant. It is important to be able to establish a standard against which newer polishers can be assessed. Traditionally, flexible aluminum oxide discs were viewed as the most effective at producing a low Ra[32–35] and this may be why they were the most commonly tested comparator against newer polishers (Table 7). It is important to consider the shape and flexibility of polishing systems[36] as well as the hardness of the abrasive and grit size.[37] An effective polisher in the incisal, flat region may not be suitable for use in the convex cervical area due to the difference in anatomical form Reference 36.

Within the selected papers there was disagreement regarding the influence of composite composition on Ra. Figure 3 shows microhybrid to perform poorer than other composite compositions however Figure 2 shows variations in performance of different microhybrids. Examining the data presented appears to show that the majority of microhybrid composites perform poorer than other composites regardless of polishing systems and that microfilled composite may be more predictably polished (Figures 2–4). With consideration that most of the data for microhybrid composites came from one paper[26] it is impossible to state from this review that microhybrids perform worse than other compositions of composite as there could be an influence by a different variable. This is demonstrated by the different outcomes achieved by Scheibe et al.[26] and Barbosa et al.[20] in Figure 2 despite the same material and finishing/polishing protocol followed. Barbosa et al.[20] observed a statistically significant ($P < 0.05$) difference between microfilled composites and a hybrid composite. AlJazairy et al.[23] observed lower Ra for nanohybrid compared to microhybrid composite but this was neither statistically nor clinically significant. St

TABLE 7 Overview of number of studies evaluating different polishing systems against composite type.

Polishing System	Classification of composite (*n*) Microfill	Nanofill	Nanohybrid	Microhybrid	Total (*n*)
Astropol	1	1	3	2	**7**
Astropol and astrobrush	–	2	2	–	**4**
HiLuster Plus	1	1	2	–	**4**
D-Fine	1	2	3	–	**6**
Diacomp	1	1	2	–	**4**
ET Illustra	1	1	2	–	**4**
Sof-Lex Wheels	1	1	2	–	**4**
Sof-Lex discs	6	4	4	11	**25**
Super-Snap	5	3	4	2	**14**
Enhance/PoGo	2	4	3	7	**16**
PoGo	–	–	1	1	**2**
Optrapol	1	1	3	1	**6**
One Gloss	1	1	2	–	**4**
Composi Pro Brush	1	1	2	–	**4**
Rubber points, paste and felt polishing disc	2	–	–	1	**3**
Rubber points, paste and felt polishing disc and diamond burs	2	–	–	1	**3**
Tungsten carbide bur	–	1	1	–	**2**
Flame point prepolisher and shine	–	1	1	–	**2**
Flexi-discs and enamelize	1	1	1	–	**3**
Optidisc	–	1	2	–	**3**
Opti1step and optiShine	–	1	2	–	**3**
Opti1step and superPolish	–	1	2		**3**
Felt disc and Diamond paste	–	–	–	5	**5**

Pierre et al.[22] state that microfilled Durafill VS was more predictably polished but this was not a statistically significant finding. No clear relationship between final Ra and polished nanofilled and microfilled composites was identified by Berger et al.[19] In agreement with the findings from this review, evidence within the wider scientific literature is not conclusive. A systematic review by Kaizer et al.[6] and a 7-year clinical study by Lempel et al.[38] concluded that there was insufficient evidence that nanofilled and submicron composites show improved Ra compared to microhybrid composite. Not all scientific literature supports this finding and some there is evidence to support particle size as an influence on Ra.[39–41] Combination of filler size alongside factors such as composition of resin matrix[37] and its elasticity,[42] monomer structure,[43] obtainable degree of polymerization, particle distribution and fixation between filler and matrix may play a role in polishability.[44]

Results from the most tested polishers (Figures 2–4) highlighted a need to establish whether outcomes of polishing procedures were influenced by finishing procedure (Figures 5–7). Whilst confidence in results viewed in this way is reduced due to heterogeneity between studies, it helped to substantiate patterns observed within studies. Both Sof-Lex discs and Enhance/PoGo preceded by no finishing and finishing with tungsten carbide achieved mean Ra below the threshold value for all varieties of composite tested. Ra was not influenced by finishing procedure when using Super-Snap discs however it is noted that this observation is based on a smaller number of tested combinations. Daud et al.[11] and Santos et al.[27] found that finishing with fine diamond burs produced a higher, statistically significant ($P < 0.0001$) and clinically relevant (above the threshold value) Ra compared to fine tungsten carbide burs. Baseren[25] found no difference between super-fine diamond burs and tungsten carbide burs.

Similar to the findings of this review, evidence for[45,46] and against[15] the increase in Ra when diamond burs are used compared to tungsten carbide burs is found within the scientific literature. Alternatively, it may be the grit of the finisher which is important; increased Ra when fine diamond burs are compared to fine tungsten carbide burs and no difference when comparing ultrafine diamond burs to ultrafine tungsten carbide.[47] Studies which tested with no prior finishing procedure or using medium-grit polishers may be viewed as less

TABLE 8 Summary of risk of bias assessment.

	Selection bias		Performance bias		Attrition/ exclusion bias	Detection bias		Selective reporting bias	Other biases	
	Was administered dose or exposure level adequately randomized?	Was allocation to study groups adequately concealed?	Were experimental conditions identical across study groups?	Were the research personnel and human subjects blinded to the study group during the study?	Were outcome data complete without attrition or exclusion from analysis	Can we be confident in the exposure characterization?	Can we be confident in the outcome assessment?	Were all measured outcomes reported?	Were there any unintended co-exposures?	Were potential conflicts of interest declared?
St Pierre et al.[22]	+	−	++	NR	−−	+	+	+	NR	++
Al Jazairy et al.[23]	−	−	++	NR	+	+	+	+	+	+
Daud et al.[11]	+	−	++	NR	+	−	−	+	NR	−
Santos et al.[27]	+	−	+	NR	+	+	−	+	NR	−
Avsar et al.[24]	−	−	++	NR	+	−	+	−	NR	+
Berger et al.[19]	+	−	++	NR	+	−	−	+	+	+
Scheibe et al.[26]	−	−	−	NR	+	−	+	+	NR	−
Sarac et al.[21]	−	−	−	NR	+	+	+	+	NR	−
Barbosa et al.[20]	+	−	++	NR	+	−	+	+	NR	−
Baseren.[25]	−	−	++	NR	+	−	+	+	NR	−
Babina et al.[12]	+	−	++	NR	+	−	−	+	NR	+

Definitely low risk of bias ++
Probably low risk of bias +
Probably high risk of bias OR Not Reported (NR) − NR
Definitely high risk of bias −−

TABLE 9 Outcomes of studies.

Authors and published year	Polishing system	Composite material	Surface roughness (μm) and standard deviation	Study findings
St-Pierre, Martel, Crepeau and Vargas, 2019[22]	Astropol	Durafill Vs	0.1814 ± 0.0323	An interaction between polisher and type of composite found. Astropol, Hilustre Plus, D-fine, ET Illustra, Sof-lex discs, Super-snap and Optrapol all within threshold for all composites tested. OneGloss and Composipro Brush (both one-step systems) failed to meet mean surface roughness threshold. Where results were mixed for different composites tested, Durafill Vs was most predictably polished. Additional factors which may influence outcome are operator, bacterial biodegradation, alcohol and acidic exposure over time.
		Filtek Supreme Ultra	0.1675 ± 0.0372	
		Grandio SO	0.1645 ± 0.0561	
		Venus Pearl	0.1415 ± 0.0288	
	HiLuster Plus	Durafill Vs	0.1520 ± 0.0388	
		Filtek Supreme Ultra	0.1623 ± 0.0254	
		Grandio SO	0.1840 ± 0.0343	
		Venus Pearl	0.1790 ± 0.0269	
	D-Fine	Durafill Vs	0.1277 ± 0.0484	
		Filtek Supreme Ultra	0.1535 ± 0.0465	
		Grandio SO	0.1822 ± 0.0308	
		Venus Pearl	0.1831 ± 0.0403	
	Diacomp	Durafill Vs	0.1805 ± 0.0363	
		Filtek Supreme Ultra	0.1844 ± 0.0261	
		Grandio SO	0.2014 ± 0.0375	
		Venus Pearl	0.1845 ± 0.0340	
	ET Illustra	Durafill Vs	0.1842 ± 0.0368	
		Filtek Supreme Ultra	0.1947 ± 0.0607	
		Grandio SO	0.1781 ± 0.0371	
		Venus Pearl	0.1799 ± 0.0219	
	Sof-Lex Wheels	Durafill Vs	0.1752 ± 0.0358	
		Filtek Supreme Ultra	0.2450 ± 0.0424	
		Grandio SO	0.2376 ± 0.0349	
		Venus Pearl	0.2364 ± 0.0503	
	Sof-Lex discs	Durafill Vs	0.1908 ± 0.0515	
		Filtek Supreme Ultra	0.1983 ± 0.0370	
		Grandio SO	0.1990 ± 0.0412	
		Venus Pearl	0.1678 ± 0.0317	
	Super-Snap	Durafill Vs	0.1975 ± 0.0458	
		Filtek Supreme Ultra	0.1213 ± 0.0227	
		Grandio SO	0.1494 ± 0.0201	
		Venus Pearl	0.1567 ± 0.0292	
	Enhance/PoGo	Durafill Vs	0.1737 ± 0.0653	
		Filtek Supreme Ultra	0.2848 ± 0.0646	
		Grandio SO	0.2334 ± 0.0723	
		Venus Pearl	0.2193 ± 0.0795	
	Optrapol	Durafill Vs	0.1478 ± 0.0283	
		Filtek Supreme Ultra	0.1535 ± 0.0420	
		Grandio SO	0.1628 ± 0.0350	
		Venus Pearl	0.1523 ± 0.0382	
	One Gloss	Durafill Vs	0.6323 ± 0.0958	
		Filtek Supreme Ultra	0.5068 ± 0.896	
		Grandio SO	0.4000 ± 0.0784	
		Venus Pearl	0.3520 ± 0.0583	

TABLE 9 (Continued)

Authors and published year	Polishing system	Composite material	Surface roughness (μm) and standard deviation	Study findings
	Composi Pro Brush	Durafill Vs	0.3944 ± 0.0859	
		Filtek Supreme Ultra	0.4958 ± 0.0834	
		Grandio SO	0.3325 ± 0.0383	
		Venus Pearl	0.3135 ± 0.0687	
AlJazairy, Mitwalli, AlMoajel, 2019[23]	PoGo	IPS empress direct	0.060 ± 0.064	Statistically significant difference observed between different combinations of polishing systems and composite materials but not clinically significant. In agreement with hypothesis, all combinations less than threshold. Other outcomes; Curing under mylar recommended to reduce amount of oxygen inhibiting layer which is uncured, sticky and soft. Limitations of in-vitro recognized due to flat surface - not same clinically.
		Filtek P90	0.108 ± 0.101	
	Optrapol	IPS empress direct	0.067 ± 0.070	
		Filtek P90	0.114 ± 0.110	
Daud, Gray, Lynch, Wilson and Blum, 2018[11]	PoGo & diamond bur	Filtek Supreme XTE	0.25	No clinically significant differences between different composites. Other findings; Finishing protocol more important than polishing - tungsten carbide bur to finish recommended.
		Filtek Z250	0.25	
	PoGo & Tungsten Carbide	Filtek Supreme XTE	0.09	
		Filtek Z250	0.1	
	Sof-Lex & Diamond	Filtek Supreme XTE	0.23	
		Filtek Z250	0.25	
	Sof-Lex & Tungsten	Filtek Supreme XTE	0.16	
		Filtek Z250	0.16	
Santos, Regos, Linares, Rizkalla and Santos Jr., 2017[27]	Tungsten carbide bur	tetric evo-ceram	0.126 ± 0.07	Flame point failed to achieve below threshold for both composites tested. All preceded by diamond finishing bur which resulted in all values prior to polishing greater than 0.2. Study shows you should polish after finishing.
		Filtek Supreme Ultra	0.142 ± 0.01	
	D-Fine	tetric evo-ceram	0.124 ± 0.03	
		Filtek Supreme Ultra	0.116 ± 0.02	
	Flame point prepolisher and shine	tetric evo-ceram	0.200 ± 0.08	
		Filtek Supreme Ultra	0.223 ± 0.08	
Avsar A, Yuzbasioglu, Sarac, 2015[24]	Sof-Lex	Grandio	0.375 ± 0.15	Combination of Sof-lex + nanofill under threshold. Info in abstarct wrong and two Ra values (SR + AE/P) exactly the same? Is this possible or not recorded correctly?
		Ice	0.344 ± 0.16	
		Smile	0.320 ± 0.06	
		Aelite enamel	0.156 ± 0.06	
		Premise	0.188 ± 0.08	
		Filtek Supreme XT	0.181 ± 0.04	
	Silicon rubber (Kerr)	Grandio	0.406 ± 0.11	
		Ice	0.504 ± 0.16	
		Smile	0.598 ± 0.06	
		Aelite enamel	0.314 ± 0.09	
		Premise	0.341 ± 0.09	
		Filtek Supreme XT	0.305 ± 0.10	
Berger, Palialol, Cavalli, Giannini, 2011[19]	Sof-Lex	Filtek supreme plus	0.1 ± 0.038	In agreement with the hypothesis, a clinically acceptable outcome regardless of composite and polisher combination with all results lower than threshold value. The smallest filler size does not guarantee the smoothest surface.
		Esthet-X	0.125 ± 0.03	
		Renamel Microfill	0.082 ± 0.019	
	Enhance+PoGo	Filtek supreme plus	0.084 ± 0.009	
		Esthet-X	0.09 ± 0.037	
		Renamel Microfill	0.096 ± 0.018	

(Continues)

TABLE 9 (Continued)

Authors and published year	Polishing system	Composite material	Surface roughness (μm) and standard deviation	Study findings
	Filtek supreme plus	Flexi-discs and enamelize	0.126 ± 0.045	
		Esthet-X	0.116 ± 0.014	
		Renamel Microfill	0.084 ± 0.017	
Sarac, Sarac, Kulunk, Ural and Kulunk, 2006[21]	Sof-Lex	Grandio	0.79 ± 0.04	In agreement with the hypothesis, the combination of composite and polisher did not influence the result. Other outcomes; all results improved with the application of glaze.
		Filtek Z250	0.82 ± 0.05	
		Quadrant universal LC	1.60 ± 0.07	
	Astropol	Grandio	0.96 ± 0.06	
		Filtek Z250	1.30 ± 0.10	
		Quadrant universal LC	1.83 ± 0.08	
Barbosa, Zanata, Navarro and Nunes, 2005[20]	Sof-Lex	Durafill	0.11 ± 0.04	Not all combinations of composite and polisher produced results below threshold value. Sof-lex without prior finishing ok for all. Rubber points, paste and disc not below threshold for any composite or finishing protocol. Super snap above threshold for hybrid. Where results mixed, Durafill predictably polished. Other outcomes; use of diamond finishing bur increases final Ra.
		Perfection	0.12 ± 0.05	
		Filtek Z250	0.11 ± 0.07	
	Sof-Lex and diamond burs	Durafill	0.18 ± 0.07	
		Perfection	0.24 ± 0.07	
		Filtek Z250	0.19 ± 0.03	
	Super-Snap discs	Durafill	0.17 ± 0.04	
		Perfection	0.14 ± 0.04	
		Filtek Z250	0.33 ± 0.13	
	Super-Snap and diamond burs	Durafill	0.06 ± 0.01	
		Perfection	0.14 ± 0.01	
		Filtek Z250	0.27 ± 0/10	
	Rubber points, paste and felt polishing disc	Durafill	0.29 ± 0.11	
		Perfection	0.36 ± .06	
		Filtek Z250	0.49 ± .13	
	Rubber points, paste and felt polishing disc and diamond burs	Durafill	0.25 ± 0.64	
		Perfection	0.27 ± 0.05	
		Filtek Z250	0.34 ± 0.08	
Baseren, 2004[25]	Super-Snap rainbow +diamond bur	Filtek Supreme	0.13 ± 0.08	The results of this study would indicate that choice of polisher is more important than composite. Supersnap below threshold independent of filler type and finishing protocol. This study states that acceptable range is 0.7–1 um which would place all combinations within the acceptable range.
		Grandio	0.15 ± 0.05	
	Super-Snap +tungsten carbide	Filtek Supreme	0.11 ± 0.02	
		Grandio	0.14 ± 0.21	
	Astropol and astrobrush + diamond	Filtek Supreme	0.39 ± 0.04	
		Grandio	0.34 ± 0.02	
	Astropol and astrobrush + tungsten carbide	Filtek Supreme	0.33 ± 0.02	
		Grandio	0.32 ± 0.01	

TABLE 9 (Continued)

Authors and published year	Polishing system	Composite material	Surface roughness (μm) and standard deviation	Study findings
Babina, Polyakova, Sokhova, Doroshina, Arakelyan and Novozhilova, 2020[12]	Optidisc	Premise	0.08 ± 0.02	The results of this study indicate that type of polisher is more influence on Ra than composite type. Aluminum oxide discs performed well on all nanohybrids.
		Herculite ultra	0.08 ± 0.01	
		Harmonize	0.12 ± 0.08	
	Opti1step and optiShine	Premise	0.22 ± 0.13	
		Herculite ultra	0.15 ± 0.09	
		Harmonize	0.23 ± 0.15	
	Opti1step and superPolish	Premise	0.29 ± 0.18	
		Herculite ultra	0.23 ± 0.04	
		Harmonize	0.10 ± 0.06	
Schiebe, Almeida, Medeiros, Costa and Alves, 2009[26]	Enhance + PoGo	Charisma	0.3363 ± 0.25	Only Z250 with felt disc below threshold. Finishing performed with diamond burs first.
		Fill Magic	0.5813 ± 0.28	
		TPH spectrum	0.5724 ± 0.22	
		Z100	0.4519 ± 0.10	
		Z250	0.4443 ± 0.19	
	Felt disc and Diamond paste	Charisma	0.5080 ± 0.34	
		Fill Magic	0.4748 ± 0.29	
		TPH spectrum	0.9359 ± 0.07	
		Z100	0.2769 ± 0.18	
		Z250	0.1846 ± 0.06	
	Sof-Lex	Charisma	1.1007 ± 0.44	
		Fill Magic	1.1276 ± 0.63	
		TPH spectrum	1.3663 ± 0.032	
		Z100	0.9798 ± 0.48	
		Z250	0.6548 ± 0.39	

relevant clinically when it is accepted that finishing is likely to be required. Whist there is conflicting evidence regarding the influence of finishing devices, the need to polish after finishing is supported. AlJazairy et al.,[23] Santos et al.[27] and Barbosa et al.[20] found a statistically significant ($P < 0.0001$, $P < 0.05$, and $P < 0.05$, respectively) and clinically relevant difference between the Ra of polished and unpolished surfaces after finishing. This finding is supported in the literature.[15,36,37,46]

It is not possible to assess the effect of delayed finishing based on the evidence in this review. Most studies delayed polishing procedures by 24 h.[11,12,19,20,22,23,25–27] St Pierre et al.[22] were the only included study that polished immediately with no apparent difference in Ra. The importance of delayed or immediate finishing is debated. Manufacturers advise finishing immediately or 5 min after composite placement[36] opposed to the advice to delay finishing in order to improve marginal seal,[36] prevent heat generation until full polymerization has occurred and avoid smearing of the resin rich layer.[48] Clinically, it is unlikely that a desirable shape and contour will be achieved after initial composite placement and some degree of finishing will be required immediately after placement therefore this is an important effect to establish.

St Pierre et al.,[22] AlJazairy et al.[23] and Babina et al.[12] identified the possible influence of operator experience and handling. Polishing time, speed of handpiece, pressure applied, hand skill and experience of operator may be important variables.[12,22] Skill and experience of operator is a difficult variable to control. A range of experience would improve the robustness of studies but not assess levels of skill. This may be a reason for variability in outcomes when all other factors are controlled. Specifically with regards to polishers, familiarity with polishers may have an influence regarding direction of force and the amount of pressure applied which may influence the formation of surface irregularities.[37]

No clear relationship emerged regarding the shape of the composite surface and Ra. The majority of trials[11,19–21,23,25–27] polished flat surfaces of composite. St Pierre et al.[22] used a convex mold and Babina et al.[12] restored class V cavities on extracted teeth. The study by Babina et al.[12] tested polishers on extracted teeth opposed to surfaces produced through molds (Table 6). They noted that aluminum

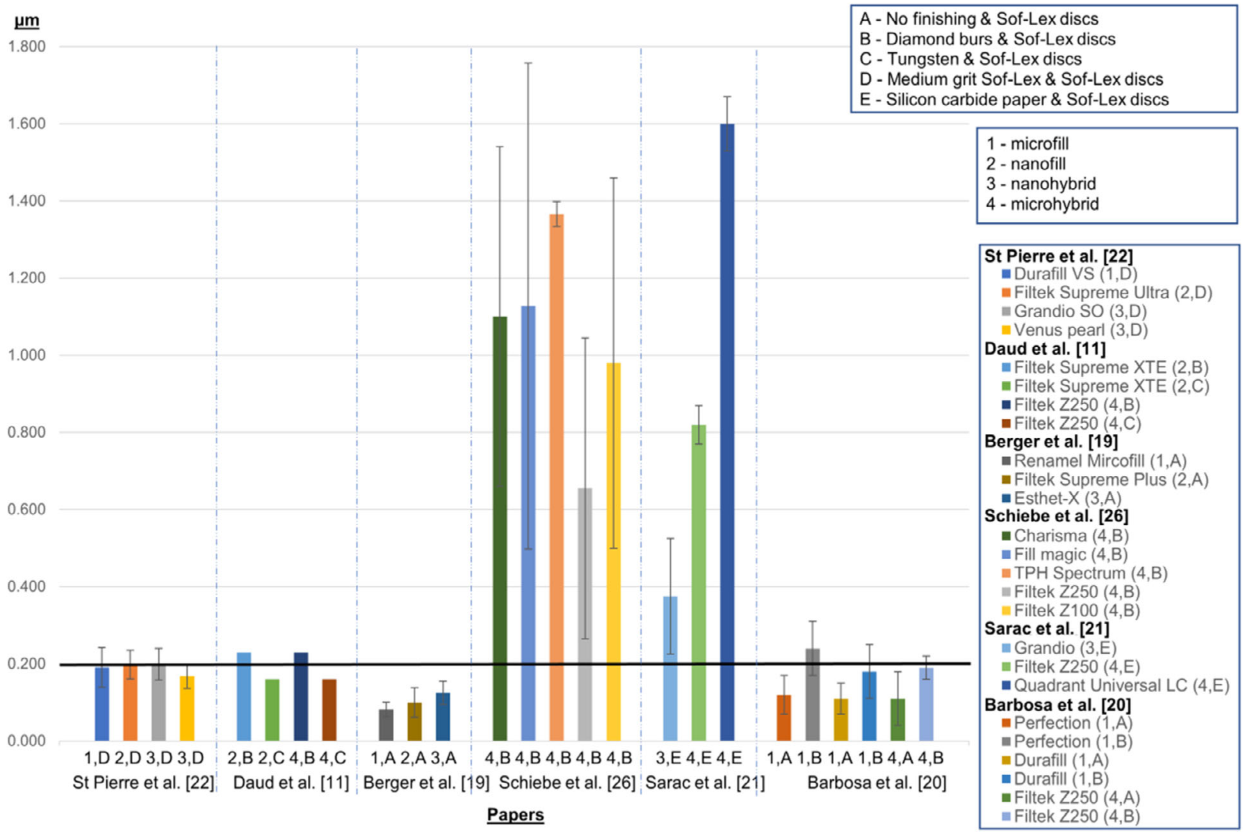

FIGURE 2 Outcome of trials which tested Sof-Lex discs.

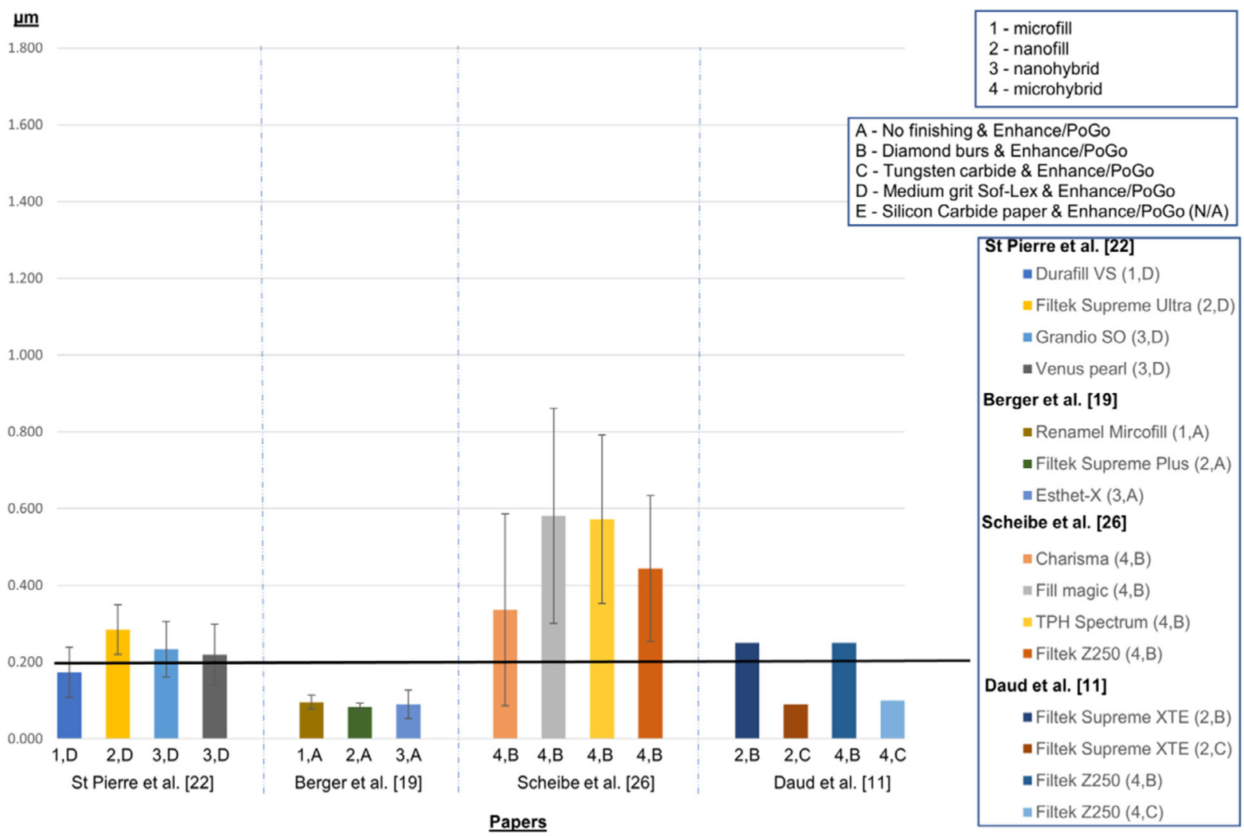

FIGURE 3 Outcome of trials which tested Enhance/PoGo.

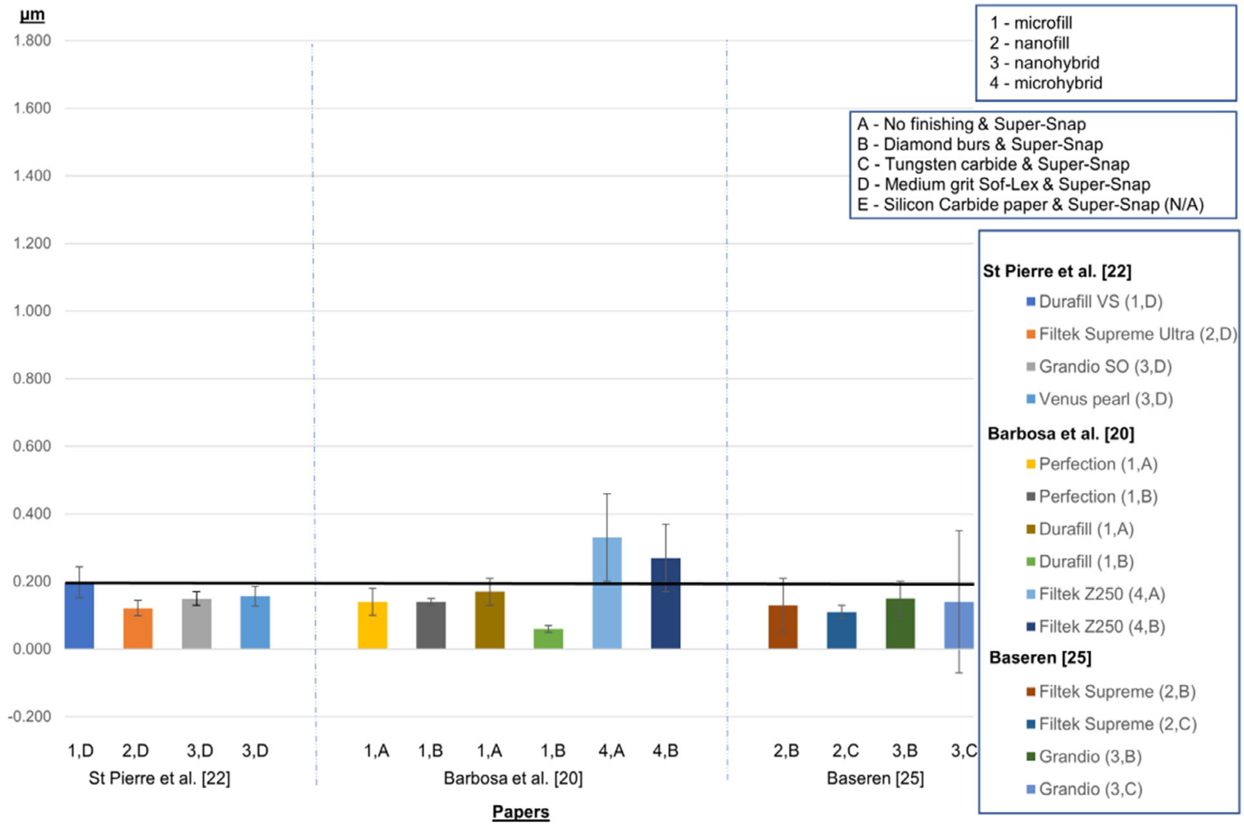

FIGURE 4 Outcome of trials which tested Super-Snap discs.

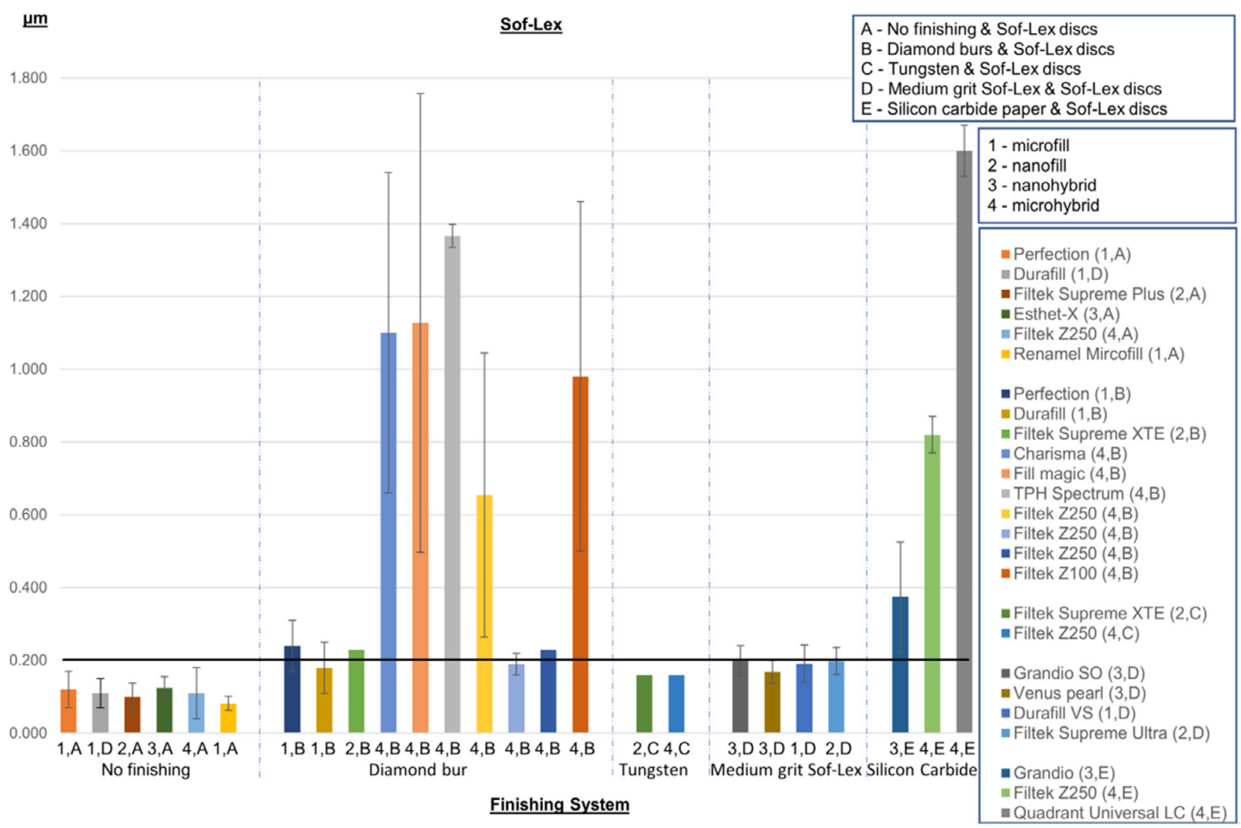

FIGURE 5 Outcomes for Sof-Lex discs grouped according to the finishing procedure.

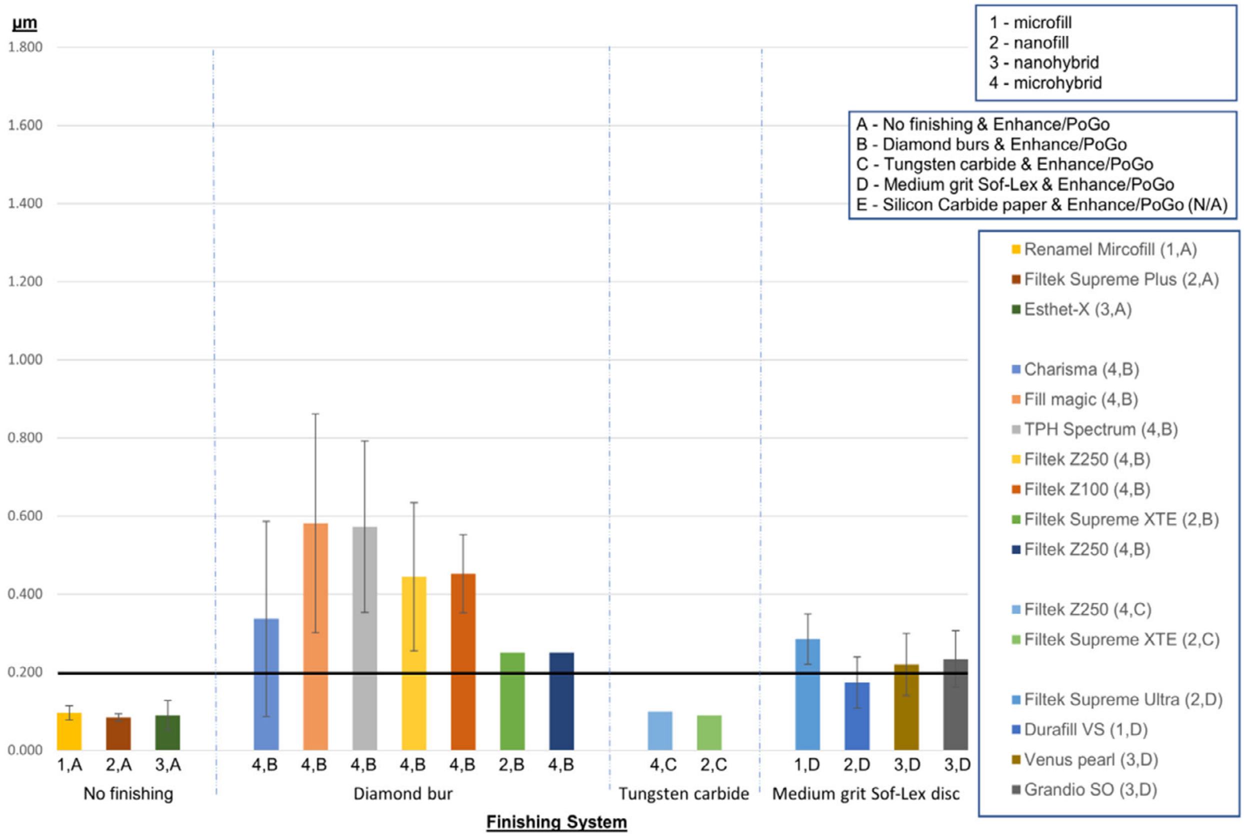

FIGURE 6 Outcomes for Enhance/PoGo grouped according to the finishing procedure.

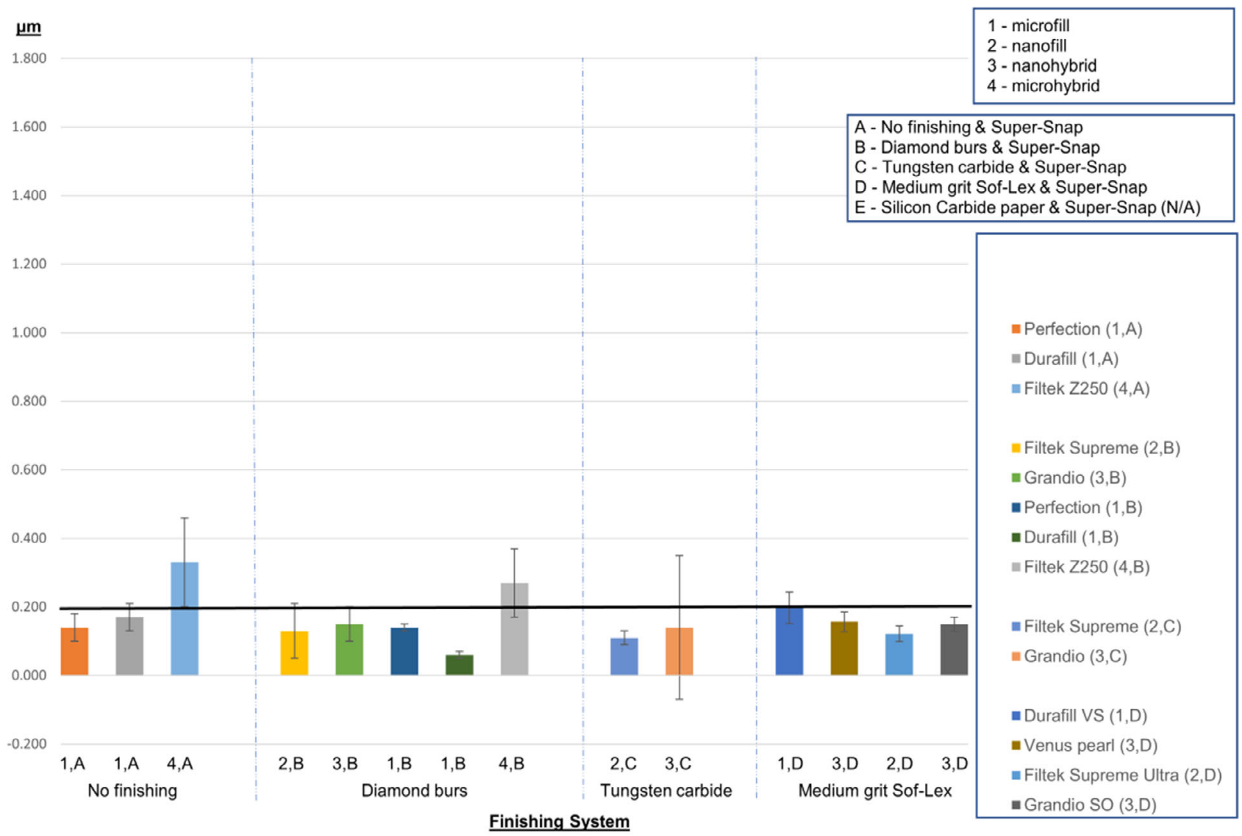

FIGURE 7 Outcomes for Super-Snap discs grouped according to the finishing procedure.

TABLE 10 Key limitations identified within studies.

Limitation	Implication
Small sample sizes	Insufficiently powered results: the results could be as a result of a random effect or influenced by risk of bias.[51] Included papers were limited to a sample size greater than seven however this is an arbitrary number chosen by the author. For future studies, a suitable sample size for valid statistical testing should be determined by a statistician to improve the power and value of the results.[51]
Differences in methodology	Different methods of attempting to control variables aligned with necessary clinical practice such as; finishing procedures, timing of polishing, operator skill and experience as well as the composition of composite used does not enable comparison across studies.[11]
Risk of bias	The moderate risk of bias across all studies reduces the confidence of the results.

oxide disc performed well on the composite surface and composite/enamel interface whereas silicon polishers and brushes impregnated with silicon carbide performed better at the composite/cementum interface. In agreement with the finding that devices perform differently in different areas, a study found that whilst the Ra at the interface on enamel and on composite was affected by choice of finisher, there was no difference at the composite-dentine interface.[47] Effects of finisher/polisher on tooth tissue is an important consideration when assessing overall effectiveness.[12]

It is not possible to determine an effect of reduced polishing stages from this review due to the low numbers of single-step polishers reported on. Within the literature, there is evidence for[49,50] and against[50] multi-step systems outperforming single-step systems. The study which reported a poor outcome reported for the multi-step system tested a relatively new product to the market; Sof-Lex spiral.[50]

Confidence in results is limited due to low sample numbers, heterogeneity of materials and methods, serious risk of bias in all papers and disagreement between results (Table 10).

This review is limited by having only one reviewer undertake the screening and selection process and having a second reviewer would reduce risk of bias from this stage of the review. However a second reviewer was involved in checking the risk of bias assessments and the data extraction to reduce the risk of errors and the review has been conducted in accordance with Cochrane guidelines. The review is also limited by the limited number of databases searched for eligible studies.

Whilst clinical recommendations are limited by the available evidence, the results of this review may serve as a guide to future research.

Table 11 lists the features of future studies to meet the aim of this review and generate a standard against which polishers could be measured. This could then be tested to see if the results were similar when tested in-vivo.

TABLE 11 Features for inclusion in the future studies.

Recommendations for future research	Impact
Increase sample sizes under guidance of statistician	Increases in sample sizes increases confidence in results
Standardize finishing sequence to reflect clinical practice. Consider gross finishing with diamond followed by tungsten carbide/medium grit Sof-Lex disc.	More applicable and useful to clinical practice.
Compare immediate finishing to delayed finishing	Whilst delayed finishing is accepted as preferable this is not clinically realistic and it is important to be aware of the potential implications of immediate finishing.
Explain the rationale for choosing composite materials and polishing systems	Reduce the risk of manufacturer bias
Include a conflict of interest statement	Reduce the risk of bias
Explain any level of and any variety in operator skill and experience	Enables assessment of operator influence
Randomize allocation of composites	Increase level of evidence and reduce the risk of bias
Blind operators to composite material and blind assessors to both composite material and polishing system	Increase level of evidence and reduce the risk of bias

5 | CONCLUSION

The hypothesis: a clinically acceptable Ra of under 0.2 μm will be produced regardless of combination of composite and polisher is rejected. Not all combinations of resin composite and polisher produce Ra of less than 0.2 μm. We have identified a number of combinations of polisher and resin composite which produce an Ra of less than 0.2 μm in-vitro but because of a paucity of available evidence were unable to determine a recommendation of which combination is best. Type of finishing instrument used prior to polishing appears to be an important factor in determining final Ra. More clinically robust research is needed to answer the question of whether specific combinations of resin composite and polishing systems achieve better outcomes than others. Furthermore, in vivo studies are needed to establish whether the results achieved in vitro can be achieved in clinical practice.

ACKNOWLEDGMENTS

The authors thank the University of Warwick and family and friends for support in completing this review. The authors declare no personal or commercial interest in the content of this review.

CONFLICT OF INTEREST STATEMENT

We wish to confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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How to cite this article: Devlukia S, Hammond L, Malik K. Is surface roughness of direct resin composite restorations material and polisher-dependent? A systematic review. *J Esthet Restor Dent*. 2023;1-21. doi:10.1111/jerd.13102