

2023

## Pinch Force Generation During Scaling by Dental Professionals: A Systematic Review

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### Original Publication Citation

Suedbeck, J. R., & Ludwig, E. A. (2023). Pinch force generation during scaling by dental professionals: A systematic review. *International Journal of Dental Hygiene*, 21(3), 514-523. <https://doi.org/10.1111/idh.12649>

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## REVIEW ARTICLE

# Pinch force generation during scaling by dental professionals: A systematic review

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**Abstract**

**Objective:** The objective of this review was to examine the impact of instrument designs on pinch force generation during scaling by dental professionals.

**Methods:** Three databases were utilized from September 2019 to November 2021 in addition to hand-searching specific journals and reference lists. Research articles that examined pinch force generation in dental professionals during scaling with manual instruments only were included. Bias was assessed in the individual articles.

**Results:** Six research articles were included with sample populations that varied from 12 to 24 participants. Four articles evaluated instrument designs in relation to pinch force generation during scaling by dental professionals. Two articles evaluated the clinicians' experience levels and the impact on pinch force generation. Results of three articles revealed instruments with large diameters and low weights produced the least amount of pinch force ( $p < 0.05$ ). Additionally, two articles found instruments with a round, tapered shape produced less pinch force and instrument handles made of silicone produced higher pinch strength post-scaling ( $p < 0.05$ ). One study indicated instrument designs associated with modified scaling techniques may reduce thumb and index finger pinch force ( $p < 0.05$ ).

**Conclusion:** The findings from this review indicate weak evidence for instrument choices to reduce pinch force during scaling. Dental professionals should consider lightweight and large diameter instruments for manual scaling. Clinicians may also want to consider round, tapered handles and instrument designs with modified scaling techniques. This systematic review further identified the need for clinical research studies with rigorous research designs that examine the ergonomic impacts of instrument designs.

**KEYWORDS**

dental, ergonomics, instrumentation, musculoskeletal disorder, pinch force

## 1 | INTRODUCTION

Dental professionals are at an increased risk for developing musculo-skeletal disorders (MSDs) leading to negative impacts on the clinician's personal health, career satisfaction and career longevity.<sup>1-6</sup> Clinical practice for dental professionals requires repetitive motions, awkward and static postures and fine motor movements in combination with forceful grips.<sup>7-18</sup> All of these factors contribute to the clinician's risk for developing occupationally related MSDs. Furthermore, research indicates dental hygienists have the highest prevalence rates of MSDs when compared to other dental professionals with many areas of the upper body and limbs being negatively affected.<sup>2</sup> Because of the risk to dental practitioners, research has sought to determine risk factors and mitigation strategies including ergonomic positioning of the clinician and patient, manual instrument selection, powered instrumentation, and the use of magnification loupes for practice.<sup>3,4,6,7,12-26</sup> Research has indicated lightweight, large diameter instruments, powered instruments, neutral positioning such as the 11 o'clock zone, and wearing loupes all reduce the risk for developing MSDs.<sup>3,4,6,7,12-26</sup>

The selection of manual instruments has always been an area of ongoing research as the repetitive motions of scaling and root debridement contribute significantly to MSD risk. Researchers have examined many aspects of instrument designs and impact on MSD risk and comfort.<sup>12-19</sup> Rempel et al. used both surface electromyography (sEMG) and pinch force sensors to determine the muscle activity and pinch force generation by dental instruments in several studies utilizing laboratory-designed instruments.<sup>13,14,16,17</sup> In separate studies, Rempel et al. examined instrument handle shapes, weights, diameters and the experience of the clinician and the results on muscle activity and pinch force generation.<sup>13,14,16,17</sup> Since then, researchers have utilized the same technologies (sEMG and pinch force) to examine the effects of commercially available instruments, newer technologies such as silicone-handled instruments, scaling techniques associated with various instrument types and other dental equipment such as handpieces.<sup>15,18,21,22</sup>

Although there are several studies examining the effects of instrument handle designs on MSD risk, there has been little culmination of the information in systematic reviews, meta-analyses or practice guidelines. Therefore, the objective of this systematic review is to determine the effects of various dental instrument designs (compared to each other) on pinch force generation in dental professionals.

## 2 | MATERIALS AND METHODS

### 2.1 | Protocol development

The protocol for this systematic review was developed 'a priori' as part of a research course. The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Guidelines were utilized for this systematic review<sup>27</sup>; however, this review was not registered with Prospero due to the student status of the researchers at the

time of the project by the direction of the course instructor. Upon completion of the course, data extraction had already occurred, and the study no longer met the criteria for Prospero registration.

### 2.2 | Search strategy

The literature search included the use of several databases: PubMed, Dentistry and Oral Sciences Source, and CINAHL Plus between September 2019 and November 2019; the same databases were searched again in November 2021 with the same parameters to ensure new articles were included in the systematic review due to the time elapsed from the course assignment. These databases were searched using a combination of subject headings, MeSH terms, and key words including *dental AND 'pinch force' OR 'grip force' AND 'instrument'*. Searches included all languages and all years to be all-inclusive and due to the limited number of publications on the topic. In addition to database searches, reference lists of articles were hand-searched and specific journals' table of contents were searched for relevant articles; these journals included *The Journal of Dental Hygiene*, *The International Journal of Dental Hygiene*, *The Journal of Dental Education*, *The Journal of the American Dental Association*, *The Canadian Journal of Dental Hygiene*, *The Journal of Dentistry*, and *The Journal of Dental Research*. Finally, corresponding authors were contacted in an effort to include grey literature such as unpublished data and results in pinch force generation.

### 2.3 | Study selection

Once duplicates were removed, articles were first screened by title and then abstract for inclusion in the systematic review. Articles were removed if they were not research in dentistry, did not include manual scaling and root debridement instruments, or if they did not include the correct outcome measure of pinch force generation. Research articles that were not removed during the title and abstract screening were then assessed by full text for inclusion by two independent reviewers (J.S. and E.L.) to reduce bias. All research designs were included in this systematic review due to the limited number of research studies that have examined pinch force generation during manual scaling by dental professionals. Conference abstracts, literature reviews, editorials, expert opinions and non-research manuscripts were not eligible for inclusion in this systematic review. Additionally, articles that were published in duplicate (e.g. dissertations then published as research articles) were removed as duplicates during the full-text review. This study selection process is shown in the flow diagram of Figure 1.<sup>27</sup>

### 2.4 | Data extraction

Two independent reviewers (J.S. and E.L.) completed data extraction for full-text articles that met the inclusion criteria;

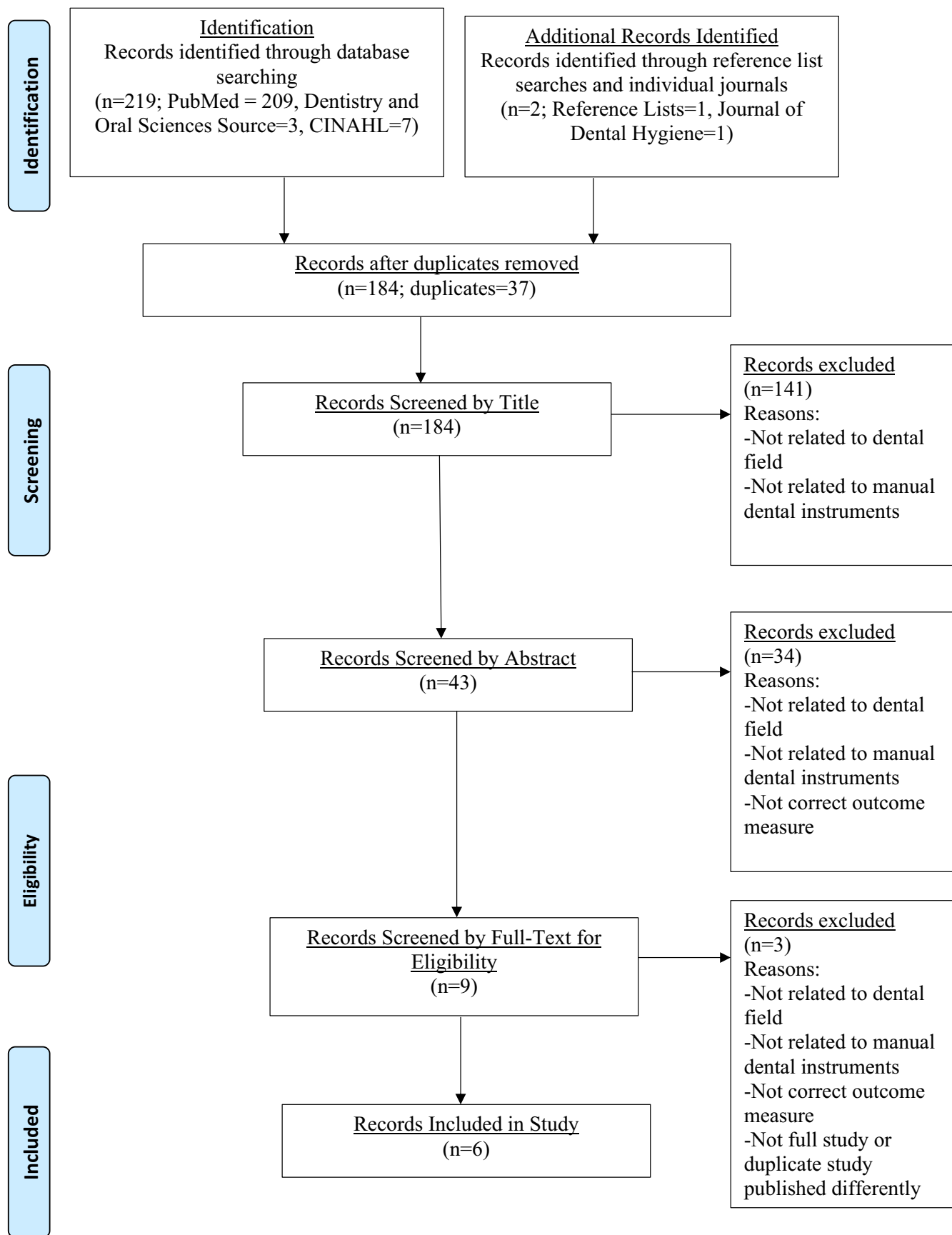


FIGURE 1 PRISMA study selection flow chart

independent reviews were conducted to reduce bias. Researchers extracted the authors, years, sample sizes, participants' characteristics, interventions, outcome measures and results. If the data extraction was different by the two reviewers independently, a discussion occurred to reach consensus about the information that should be included in the review. Had the researchers been unable to come to a consensus, the course director (S.R.) would have been contacted to reach a consensus – which was not required for this review. Two raters (J.S. and E. L.) also independently reviewed eligible articles for methodological quality using the Physiotherapy Evidence Database (PEDro) Scale; because of the varying research designs included in this systematic review, this appraisal tool was the best to capture information that could be found in all types of designs.<sup>28</sup> Furthermore, this tool is used for clinical studies and all of the eligible articles were clinical studies.<sup>28</sup> If there was a disagreement on methodological quality scores, the reviewers had a discussion to come to consensus; again, had consensus not been reached, the course director (S.R.) would serve as a third reviewer to reach consensus. Finally, the two reviewers (J.S. and E.L.) discussed how the results compared to each other for synthesis of the systematic review results. The PEDro scale has 10 scoreable items on the checklist; articles with a score of 1–3 were considered low quality, 4–6 were considered moderate quality, and 7–10 were considered high quality on the PEDro Scale. It should be noted that the PEDro scale assesses quality of the studies including impacts to validity and reliability that could result in bias. These results are depicted in Table 1. Summary measures of the included studies were the difference in mean pinch force generation and/or pinch strength production. All studies were included in the systematic review regardless of PEDro score due to the limited number of studies examining pinch force generation in dental professionals.

### 3 | RESULTS

This review found 221 manuscripts that were subject to the systematic process of article selection as demonstrated in the flow chart (Figure 1). After duplicates were removed, titles and abstracts were screened, and full-text review, six articles were included in the results.<sup>13–18</sup> The corresponding authors were contacted in an attempt to retrieve unpublished results, however, the e-mails returned as undeliverable or there were no unpublished data shared by authors. Data extracted from the final included studies comprised authors, year, sample size and demographics, intervention, outcome measure, and results (Table 2).<sup>13–18</sup> Additionally, risk of bias was assessed using the PEDro Scale and the results are indicated in Table 1.<sup>28</sup> Differences between raters (J.S. and E.L.) rarely occurred, however, in the instance that it did, discussions resulted in consensus. All of the articles were rated moderate or high quality using the PEDro Scale as indicated in the table.<sup>13–18</sup> One study had a score of 7, four studies had a score of 5, and one had a score of 4.<sup>13–18</sup> Most studies lacked blinding of subjects, researchers, and

assessors.<sup>13–18</sup> Additionally, most studies lacked a sealed allocation sequence.<sup>13–18</sup> None of the studies reported effect sizes or confidence intervals.<sup>13–18</sup>

#### 3.1 | Sample populations

Sample sizes ranged from 12–24 participants and included a mixture of dentists, dental hygienists, dental students, and dental hygiene students depending on the clinical study.<sup>13–18</sup> Two studies included an equal number of males and females ( $N = 12$ ),<sup>13,17</sup> two studies included four males and eight females,<sup>14,16</sup> and two studies included only female participants, which is common in dental hygiene research due to the population of clinicians being predominantly female.<sup>15,18</sup> The ages varied in the studies depending on whether or not students were included (see Table 1). Participants were excluded in all of the studies if they had a current injury, previous surgery, or diagnosis of MSDs in the wrist or fingers.<sup>13–18</sup>

#### 3.2 | Interventions and outcome measures

The interventions varied among all the studies to include various types of instrument designs, as well as variables examined. However, all studies examined pinch force generation and/or pinch strength.<sup>13–18</sup> Three of the studies examined various instrument characteristics and their effect on pinch force generation during scaling.<sup>13,15,17</sup> One study examined the scaling technique associated with various instrument designs and impact on pinch force generation during scaling; in this study, researchers examined a modified scaling technique that requires reduced lateral pressure and a calculus shaving stroke to remove deposits.<sup>18</sup> The instruments utilized with this technique are titanium nitride-infused, stainless steel instruments (sharpen-free) and this technique is manufacturer recommended due to this material.<sup>18</sup> Finally, two studies examined the experience level of clinicians and its effect on pinch force generation during scaling; these studies were still included in the systematic review as the reported results were about pinch force generation and are pertinent to clinical practice by dental professionals.<sup>14,16</sup> Pinch force measurement tools varied greatly among the studies as well; in three studies, a thin sensor with little additional weight was placed on the entire length of the instrument handle to measure the participants' pinch force during scaling.<sup>13,17,18</sup> One study used a hand-held pinch gauge and dynamometer to determine pinch strength and impacts of pinch force post-scaling.<sup>15</sup> Finally, two studies utilized a large sensor on the end of the instrument that increased the instrument weight significantly (100g) to measure pinch force during scaling.<sup>14,16</sup> Additionally, five studies included instruments that are not readily available to clinicians for clinical practice today; the instruments utilized in the studies were either laboratory made or are discontinued by the companies.<sup>13–17</sup> In one study, commercially available instruments were used to determine the impacts of the scaling techniques associated on pinch force generation.<sup>18</sup>

TABLE 1 Methodological quality assessment using the PEDro Scale<sup>28</sup>

ARTICLE	ITEM 1 (no points)	ITEM 2 (Y = 1, N = 0)	ITEM 3 (Y = 1, N = 0)	ITEM 4 (Y = 1, N = 0)	ITEM 5 (Y = 1, N = 0)	ITEM 6 (Y = 1, N = 0)	ITEM 7 (Y = 1, N = 0)	ITEM 8 (Y = 1, N = 0)	ITEM 9 (Y = 1, N = 0)	ITEM 10 (Y = 1, N = 0)	ITEM 11 (Y = 1, N = 0)	TOTAL SCORE
Studies that compared types of instrument designs to other instrument designs												
Dong, Loomer, Barr, LaRoche, Young, Rempel <sup>13</sup>	Yes	Yes	No	Yes	No	No	No	Yes	Yes	Yes	No	5
Hayes <sup>15</sup>	Yes	No	No	Yes	No	No	No	Yes	Yes	Yes	Yes	5
Dong, Barr, Loomer, LaRoche, Young, Rempel <sup>17</sup>	Yes	No	No	Yes	No	No	No	Yes	Yes	Yes	Yes	5
Suedbeck, Armitano <sup>18</sup>	Yes	Yes	No	Yes	No	No	No	Yes	Yes	Yes	Yes	7
Notable studies that did not compare instruments to each other, rather compared experience of the clinicians												
Villanueva, Dong, Rempel <sup>16</sup>	No	No	No	Yes	No	No	No	Yes	Yes	Yes	No	4
Dong, Loomer, Villanueva, Rempel <sup>14</sup>	Yes	No	No	Yes	No	No	No	Yes	Yes	Yes	Yes	5

Note: Low quality = 1–3, Moderate quality = 4–6, High quality = 7–10.

Of the four studies that answered the research question on the impact of instrument design on pinch force generation during scaling, one looked at the diameters and shapes of the instrument handles,<sup>13</sup> one looked at the material of the instrument handle,<sup>15</sup> one looked at the weights and diameters of the instrument handle,<sup>17</sup> and one looked at the scaling technique associated with two instrument designs – traditional lateral pressure scaling associated with traditional instruments and reduced lateral pressure scaling associated with sharpen-free instrument designs.<sup>18</sup> The other two studies looked at overall pinch force generation in comparison with tasks with similar grips and the impact of clinician experience levels on pinch force generation.<sup>14,16</sup> The researchers felt this information was still notable for the systematic review, though it did not answer the original research question examining the impact of instrument designs on pinch force generation.

In three of the studies, researchers identified that a large diameter instrument produced the least amount of pinch force ( $p < 0.05$ ).<sup>13,15,17</sup> Additionally, one of these studies indicated a round, tapered instrument handle shape produced the least amount of pinch force,<sup>13</sup> one indicated that a silicone instrument handle increased pinch strength post-scaling thus indicating a decreased pinch force during scaling,<sup>15</sup> and one indicated that a lightweight instrument handle produced the least amount of pinch force ( $p < 0.05$ ).<sup>17</sup> Research also indicated that sharpen-free instrument designs associated with a shaving technique for scaling results in reduced overall pinch force generation, as well as individually for the thumb and index finger ( $p < 0.05$ ).<sup>18</sup> Furthermore, two studies revealed that dental professionals produced high amounts of pinch force during scaling when compared to tasks with similar grips; these ranges were indicated for increasing the risk for MSD development.<sup>14,16</sup> Results from these two studies also demonstrated experience level had a significant impact on pinch force generation with inexperienced clinicians producing significantly more pinch force than more experienced clinicians ( $p < 0.05$ ).<sup>14,16</sup>

In addition to methodological quality assessments using the PEDro Scale, bias was also assessed across the studies. Researchers identified the possibility of publication bias as five out of the six studies had significant findings reported only.<sup>13–17</sup> Furthermore, four of the six studies were conducted by the same research team, in the same location, utilizing the same populations.<sup>13,14,16,17</sup> It is possible that this also contributed to publication and reporting biases in these studies.

## 4 | DISCUSSION

Musculoskeletal disorders are a common occupational hazard for dental professionals. It is imperative that research explores and culminates the findings for ergonomic considerations that reduce the risk for MSDs including instrument design characteristics. One way to quantify this risk is through pinch force generation during scaling and root debridement by dental professionals. The findings from this systematic review provide weak, minimal evidence for ergonomic

TABLE 2 Data extraction of included studies

Authors	Year	Participants	Demographics	Sample Size	Intervention	Outcome Measure	Results	Quality Score (PEDRO)
Studies that compared types of instrument designs to other instrument designs								
Dong, Loomer, Barr, LaRoche, Young, Rempel <sup>13</sup>	2007	Dentists and Dental Hygienists	12 males and 12 females; majority aged 35–44 years	24	8 custom- designed instrument handles: round, hexagonal, tapered round, tapered hexagonal with either a 10 or 7 mm diameter; all weighed 24 g; compared different instrument shapes	Thumb pinch force	Instrument handle with a tapered, round shape and 10 mm diameter required the least pinch force when scaling	5
Hayes <sup>15</sup>	2017	Dental Hygiene Students	All females; mean age 25.4 years	23	Silicone instruments (manufacturer reports: 11.3 mm diameter and 24 g weight) compared to stainless steel (researcher reports: 10 mm diameter, 21–26 g weight)	Pinch force overall	The pinch strength was significantly stronger after instrumentation with silicone-handled instruments when compared to traditional stainless-steel instruments ( $p < 0.02$ )	5
Dong, Barr, Loomer, LaRoche, Young, Rempel <sup>17</sup>	2006	Dentists and Dental Hygienists	12 males and 12 females; majority aged 35–44 years	24	10 custom-designed dental scaling instruments with different diameters and weights; diameters ranged from 7 to 11.5 mm and weights ranged from 15 to 24 grams	Thumb pinch force	Instrument designs had a significant effect on pinch force during scale ( $p < 0.05$ ). The instrument with a large diameter and light weight produced the least amount of pinch force.	5
Suedbeck, Armitano <sup>18</sup>	2021	Dental Hygienists	12 females; ages: $n = 5$ 18–29, $n = 4$ 30–44, $n = 3$ 45–59 years old	12	Two instrument designs associated with different scaling techniques; traditional lateral pressure scaling techniques using a standard ergonomically designed instrument versus a modified scaling technique using a novel instrument designed for reduced lateral pressure	Thumb and index finger pinch force; overall pinch force	The traditional scaling technique required greater overall pinch force during scaling ( $p = 0.00$ ). Pairwise comparisons revealed significant differences between pinch force generation in the thumb for the two scaling techniques ( $Z = -2.401$ , $p = 0.016$ ) and in the index finger ( $Z = -2.223$ , $p = 0.026$ ). The traditional scaling technique generated more pinch force (thumb $x = 7.25 \pm 4.99$ , index finger $x = 2.86 \pm 2.14$ ) when compared to the modified scaling technique (thumb $x = 4.52 \pm 2.32$ , index finger $x = 1.65 \pm 1.28$ ).	7
Authors	Year	Participants	Demographics	Sample Size	Intervention	Outcome Measure	Results	Quality Score (PEDRO)
								(Continues)



TABLE 2 (Continued)

Authors	Year	Participants	Demographics	Sample Size	Intervention	Outcome Measure	Results	Quality Score (PEDRO)
Notable studies that did not compare instruments to each other, rather compared experience of the clinicians								
Villanueva, Dong, Rempel <sup>16</sup>	2007	Dental and Dental Students	4 males and 8 females; average age of dentists was 40.5 and students was 29.8 years	12	Instrument with diamond pattern surface weighing 100 g (due to added sensors); compared experience levels	Thumb pinch force	Experienced clinicians applied significantly lower peak pinch and median pinch force compared with students ( $p = 0.01$ ); overall, clinicians had high pinch forces during scaling when compared to other tasks	4
Dong, Loomer, Villanueva, Rempel <sup>14</sup>	2007	Dentists and Dental Students	4 males and 8 females; average age of dentists was 40.5 and students was 29.8 years	12	Laboratory-designed instrument (8.5 mm diameter, no weight reported)	Thumb pinch force	Students applied excessively more pinch force on tools during tasks than experienced clinicians. (students applied 46% more pinch force); both groups exhibited peak pinch forces associated with MSD risk	5

choices during instrumentation as the research designs varied greatly. Results suggest lightweight, large diameter instruments produce the least amount of pinch force thus reducing a clinician's risk for MSDs.<sup>13,15,17</sup> Though not readily reported in the individual research study, upon further investigation of specifications reported by the manufacturers, the silicone-handled instrument found to increase pinch strength post-scaling indicating less pinch force production during scaling was also lighter and had a larger diameter when compared to the stainless steel instruments.<sup>15</sup> However, many of these studies did not use clinically available instruments or instruments that are still manufactured today, therefore, the results are not easily generalizable to current scaling practices. In addition, other ergonomic considerations identified in this systematic review include using instruments with a round, tapered handle and/or silicone material.<sup>13,17</sup> One study using commercially available instruments did indicate that the scaling technique associated with sharpen-free instruments may reduce pinch force generation and thus MSD risk, however, many clinicians in this study reported concerns with burnishing calculus or more scaling strokes being required for calculus removal.<sup>18</sup> More research needs to be done in this area to determine ergonomic benefits for clinicians.

In the United States, MSDs in the hands and wrists of dental professionals are as high as 70%.<sup>29</sup> It is important dental professionals consider ergonomic recommendations that could reduce his or her risk for MSD development in these areas. As demonstrated by this systematic review, manual instrument selection is significant to hand and wrist ergonomics. The results from these studies demonstrate a reduction in MSD risk by choosing manual instruments that reduce pinch force production and increase pinch strength, for example lightweight and large diameter instruments and/or those associated with reduced lateral pressure scaling techniques, however, the evidence is minimal and weak. Because of this, dental professionals should consider specific handle characteristics when choosing instruments for scaling but may need to use additional research outcome measures such as muscle activity generation and comfort, in combination with pinch force, when selecting the appropriate instruments.

Additionally, scaling and root debridement with manual instruments was indicated for producing general pinch forces in ranges that increase a clinician's risk for MSD development when compared to activities with similar grip requirements, regardless of the handle characteristics.<sup>14,16</sup> In the late nineties, researchers determined scaling and root debridement required up to 20% of the clinician's maximum pinch force generation, therefore, increasing his or her risk for wrist MSDs.<sup>30</sup> This was further demonstrated by the results of the studies used in this systematic review.<sup>13-18</sup> Because of this, dental professionals should consider the impact of forceful grips with hand instrumentation on his or her own individual risk, especially the duration of use during each patient appointment. Research has indicated mixed results on the ergonomic impact of ultrasonic use.<sup>4,5,29-34</sup> Regardless, in most research studies, ultrasonic use has been identified to reduce MSD risk and should be considered as an adjunctive tool to manual instruments.<sup>30-34</sup> However, none of these studies examined the pinch



force generation with powered instruments. Future research should evaluate pinch force generation with powered instruments individually as well as in combination with manual instruments.

Finally, results revealed inexperienced clinicians produced higher pinch force generation during scaling when compared to more experienced clinicians.<sup>14,16</sup> This is especially important for students, dental educators, and dental hygiene educators as research indicates MSDs may occur early in the career.<sup>35–38</sup> Ergonomic recommendations for instrument kits utilized in programs should be considered. Additionally, including ergonomic considerations in the curriculum is also valuable for student clinicians early in their education. Based on these results, educators may want to consider the impact experience level has on pinch force generation; students with lack of experience may produce higher pinch force during scaling and this should be considered for the students' MSD risks while in school. Including this in instrument technique education could be impactful in reducing the students' risks for MSDs.

With a vast array of choices when it comes to instrument selection, it is vital to the health of clinicians to identify which instruments provide a reduction in MSD risk, but this may be extremely difficult. The studies included in this systematic review had small sample sizes, minimal blinding of researchers and participants, and lacked specific pertinent calculations such as power, effect size, and confidence intervals. Future studies should include more rigorous research designs with larger sample sizes and blinding protocols. Furthermore, most of the included studies examined instruments that are not readily available to clinicians and cannot be generalized to clinical practice. More research is needed to examine the effects of instrument designs on pinch force generation and other ergonomic factors using commercially available manual and powered instruments that are readily accessible to dental professionals. In addition, future research should examine the effects of a combination of instruments including powered and manual instruments. It is possible that varying instrument characteristics such as weight, diameter, shape, material, and powered or manual throughout each appointment could have an impact on overall risk for MSD and fatigue; using a combination of these characteristics may change a clinician's grip, reducing the static nature of forceful grips. This may result in pinch force reduction overall, though this has yet to be examined in clinical research.

#### 4.1 | Limitations

There are also several limitations to this systematic review. It is possible that the review missed articles due to the inability to contact corresponding authors and lack of keywords utilized in database searches. However, the researchers utilized four databases and hand searched several pertinent journals and reference lists to provide adequate results for the systematic review. Additionally, efforts were made to reach corresponding authors for grey literature. One other limitation was the use of the PEDro Scale for quality assessment. Though this is a validated tool for appraising methodological

quality, it is best utilized with randomized controlled trials. The research designs of these studies were not randomized controlled trials and it is possible that the PEDro Scale did not fully capture the quality and bias of the included studies. Because of the variability in research designs and reporting, the researchers felt this scale was still the most appropriate to use for all studies included. Finally, there were minimal original research studies that used the outcome measure of pinch force generation and/or pinch strength to determine the impact of instrument handle designs during scaling by dental professionals. This could indicate there is not enough information to truly culminate specific ergonomic recommendations. After more research studies examine pinch force generation in relation to instrument designs have been conducted, a systematic review should be repeated. Furthermore, researchers should consider using additional outcome measures such as muscle activity production in future systematic reviews of manual instrument selection impacts on MSD risk.

### 5 | CLINICAL RELEVANCE

#### 5.1 | Scientific rationale for study

Musculoskeletal disorders are common occupational hazards for dental professionals, especially dental hygienists. Despite much research on ergonomic instrument designs, the culmination of research findings is limited. This systematic review summarizes existing data on ergonomic instrument selections as they pertain to pinch force generation, a contributing factor for musculoskeletal disorder development.

#### 5.2 | Principal findings

This systematic review identified characteristics that may reduce pinch force and subsequent musculoskeletal disorder risk; using lightweight, large diameter instruments resulted in a pinch force reduction in multiple studies. Furthermore, other characteristics were noted for reducing pinch force including silicone material, round and tapered handle shapes and modified scaling techniques associated with reduced lateral pressure.

#### 5.3 | Practical implications

Dental professionals should consider ergonomic instrument designs for scaling and root debridement during clinic practice. Specifically, instruments that are designed to reduce pinch force could reduce the risk for musculoskeletal disorders. Based on the results of this review, that would include large diameter, lightweight instruments with a round, tapered handle; materials that reduce pinch force identified that should also be considered include silicone and sharpen-free technology instruments. More research is indicated for these implications.

## 6 | CONCLUSION

This systematic review indicates that using lightweight, large diameter instruments result in reduced pinch force production during scaling by dental hygienists. Sharpen-free instruments utilizing a reduced lateral pressure scaling technique also reduce pinch force generation. Finally, instruments made of silicone and/or with a round, tapered handle lowered pinch force generation. These findings indicate a decreased risk for MSDs. Results also determined that the inexperience of clinicians can contribute to increased pinch force production and MSD risk.

## AUTHOR CONTRIBUTIONS

Jessica R. Suedbeck: Conceived the ideas, collected the data, analysed the data and led the writing of the manuscript. At the time of the project, the author was a PhD student. Emily A. Ludwig: Helped with data analysing and writing of the manuscript. At the time of the project, the author was a PhD student.

## ACKNOWLEDGEMENTS

This manuscript was completed as part of PhD coursework in Kinesiology and Rehabilitation Sciences. The researchers would like to recognize Dr. Stacie Raymer for her feedback on this manuscript.

## FUNDING INFORMATION

There was no source of funding for this systematic review, and it was not registered due to the student status of the researchers at the time.

## CONFLICTS OF INTEREST

The researchers had no source of funding for this study and no conflicts of interest.

## DATA AVAILABILITY STATEMENT

Data sharing is not applicable to this article as no new data were created or analyzed in this study.

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**How to cite this article:** Suedbeck JR, Ludwig EA. Pinch force generation during scaling by dental professionals: A systematic review. *Int J Dent Hygiene*. 2023;21:514-523. doi:[10.1111/idh.12649](https://doi.org/10.1111/idh.12649)