Final Report to the
The National Institute for Occupational Safety and Health (NIOSH),
Centers for Disease Control (CDC)

Effect of Tool Design on Hand Pain in Dental Practitioners

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Abbreviations

ADA	American Dental Association
BMI	body mass index
CI	confidence interval
HR	hazard ratio
MSD	musculoskeletal disorder
N	sample size
RCT	randomized controlled trial
SD	standard deviation
UK	United Kingdom

Abstract

Background: Periodontal curette handle design may influence arm pain in dental practitioners. This 4-month randomized controlled study evaluated the effects of curette handle diameter and weight on arm pain among dental practitioners.

Methods: Dental hygienists and dentists (N=110) who performed scaling, root planing or dental prophylaxis participated. Right wrist, elbow and shoulder pain levels were assessed weekly. Participants were randomized to receive either a set of light (14 g), large diameter (11 mm) or heavy (34 g), narrow diameter (8 mm) periodontal curettes. Changes in mean pain scores across the study period were compared between treatment groups using general linear models controlling for covariates.

Results: The improvement in pain scores was greater for subjects who used the lighter, larger diameter curettes across the 3 body regions evaluated. In the final adjusted model the differences were only significant for the shoulder region (p=0.02).

Conclusions: Dental instrument design influences upper extremity pain in dental practitioners. Using a lighter, larger diameter instrument may be an easy and cost-effective intervention to reduce or prevent upper extremity pain associated with dental hygiene work.

Clinical implications: Practitioners should consider using lightweight instruments with large diameters when performing scaling and root planing in order to prevent arm pain.

Clinical Trial Registration Number: NCT01332760

Significant Findings

The study had two significant findings. First, it demonstrates that a low cost, change in dental tool handle shape and weight can reduce arm pain in dental hygienists and dentists. Dental tools are replaced every 5 to 10 years and dentists have a choice between the types of dental scaling tools they order for themselves and their dental hygienists. Dentists make decisions on which tools to buy based on many issues, such as brand familiarity, cost, longevity, etc. This study provides information on employee health that may influence the dentist's decision on which tool to buy.

Second, the study demonstrates that findings from short-term biomechanical studies in the laboratory can predict long-term health effects in workers. In this case, previous laboratory studies found that a light-weight, large diameter dental scaler reduced pinch force by approximately 30% compared to the traditional, heavier and narrow tool. Models of risk for musculoskeletal disorders predict that a reduction in pinch force reduces risk for upper extremity disorders. This RCT study confirms that the use of a tool that decreases pinch force in laboratory studies leads to reduced arm pain when the tool is used over a four month period in an epidemiologic intervention study.

The third finding was that after dentists and dental hygienists used the light-weight large diameter scaler for 4 months they applied less pinch force to whatever tool they used. That is, over time, using the lighter, large diameter tool trains dentists and dental hygienists to work with less pinch force with all the tools they use. This may be another factor in decreasing their risk, in the long-run, for developing musculoskeletal disorders.

Translation of Findings

Many dentists and dental hygienists, who spend more than 10 hours per week doing dental hygiene work, suffer from arm and shoulder pain and many retire early from the job due to disability of their arms. Dental hygiene work involves scraping the scale off of teeth with dental scaler (periodontal curette). This study found that if dentists and dental hygienists were to switch to dental tools that are lighter and larger diameter (11mm) than the traditional heavier and narrow diameter (8 mm) tools then they are likely to experience less pain in their arms. Another finding was that if they used the lighter and larger diameter tools they are also likely to use less pain medication for arm pain and to wake up less often at night due to arm pain.

There are other workplace changes that are also likely to decrease arm pain in dentists and dental hygienists and prevent injuries. These include maintaining sharp instruments, increasing rest time between patients who need heavy cleaning, and improving work postures. However, these interventions have not been formally evaluated in randomized controlled trials.

Outcomes/Impact

Already, dental tool manufacturers are offering a wider variety of periodontal curettes and other dental tool designs including tools with larger diameter handles that are lighter in weight than traditional tools. Dental hygienists appear to be gradually switching to these larger diameter lighter tools but there has been confusion about the value of these new tool designs on worker health. This study will be published next month (October 2012) in the most widely read dental journal in the country, the Journal of the American Dental Association. It is likely that the article will convince more dentists and dental hygienists to switch to these new tools. This is important because in many dental offices, the dentists are the ones who make the decision about what tools the dental hygienists use and their decision is influenced by tradition, cost and perceived tool longevity. Many dentists, therefore, have preferred to stay with the traditional heavy, narrow diameter dental tools. This study may convince dentists to change their buying habits and buy the lighter, large diameter tools for themselves and their employees. In the long run, this change in buying habits, along with other ergonomic interventions in the dental office, should lead to reduced arm pain and musculoskeletal disability among dentists and dental hygienists. This study should also lead to greater awareness of worker health issues in the dental office and the importance of considering ergonomic issues in this setting.

This study is also likely to influence the design of small, high precision tools used by other workers. Examples include the design of catheters used by cardiologists and radiologists who do invasive procedures. The tools used in other, high precision assembly and quality control jobs may also be influenced by this study and lead to less arm pain and disability in these populations.

Section 2

Scientific Report

Background

Work disability and decreased productivity due to musculoskeletal disorders of the hands and arms are common problems for dentists and dental hygienists (10-11). A survey by the American Dental Association ADA (12) reported that 9.2% of dentists had been diagnosed with upper extremity musculoskeletal disorders, of which approximately 20% required surgery and more than 40% reduced their work hours in accommodation. A survey of UK dentists found that 29.5% of premature retirements were due to similar problems (13).

Pain in the right wrist, elbow and shoulder appears to be the problem that most interferes with dental work. The prevalence of right arm symptoms among dentist and dental hygienists ranges from 19 to 61% (9, 14,15). Carpal tunnel syndrome, one of the more disabling disorders to affect the arm, is more common among dental practitioners than most other occupations (16).
Carpal tunnel syndrome and other hand and arm disorders are associated with personal (e.g., female gender, obesity, diabetes, age) and workplace factors (e.g., repetitive forceful pinching or gripping, sustained non-neutral wrist positions, and use of vibrating tools) (9, 17-19). For dental practitioners, periodontal scaling and root planing may pose the most important risk (20, 21).

A study of pinch force in a clinical setting found that dentists applied repeated peak pinch forces of 24.5 ($\pm$ 4.1) N during periodontal scaling and root planing (22). This may be a primary cause of hand and arm disorders and pain. In studies of industrial workers, repeated pinch forces over 10 N (1 kg-force) were associated with an increased risk of wrist, elbow, and shoulder disorders (19, 23-25).

Modifications to work practices that reduce the applied pinch force may play a role in preventing hand and arm disorders among dental practitioners. A recent laboratory study found that using lighter (15 v 24 g) or larger diameter (10 v 7 mm) instruments reduced the peak pinch force applied during scaling on a typodont by 23 and 17%, respectively (26). Ozawa et al. (27) found that the use of a larger diameter endodontic instrument handle (6.0 v 3.5 mm) was associated with decreased forearm muscle activity.

There have been no systematic workplace intervention studies to identify work practices or dental instrument designs that may prevent musculoskeletal disorders or decrease arm pain among dental practitioners. The purpose of this randomized controlled trial (RCT) was to evaluate the effects of periodontal instrument handle diameter and weight on arm pain among dentists and dental

hygienists who perform scaling and root planing. The hypothesis was that a lighter, larger diameter periodontal instrument would limit arm pain to a greater extent compared to the more traditional, heavier small diameter instrument.

Specific Aims

An important contribution of this proposal is that it can verify that findings from a laboratory ergonomic assessment of tools can identify workplace interventions that will reduce hand pain. This randomized controlled trail will provide evidence that ergonomic interventions, based on laboratory studies, are or are not effective in the prevention of hand pain.

The specific aims of the project are to:

1. Determine whether hand/wrist, forearm/elbow and shoulder symptoms (e.g., pain, fatigue, paresthesias) and hand function are less severe among dentists and dental hygienists who use a new dental tool in comparison to those who use a more conventional tool for performing scaling. Subjects will be randomized to use one of 2 handle designs for a 4 month period and during this time will perform their usual dental scaling work with the new tools. The effects on outcome measures will be adjusted for potential covariates (e.g., age, gender, hours scaling per week, etc.). The primary null hypothesis is: there is no difference in change in pain severity between subjects who use a new tool in comparison to those who use a conventional tool.

2. Determine whether subjective evaluations of usability and productivity of a new tool in comparison to a conventional tool are different after adjusting for potential covariates.

3. At the end of the intervention period, in a random subset sample of 40 of the participants, determine whether the applied pinch force is less among those who received the new tool in comparison to those who received the conventional tool. Participants will perform a standardized scaling task on mannequin teeth, using their assigned tool, while pinch force is measured.

4. Disseminate the study findings at dental professional conferences.

Methods

This was a 4-month cluster-randomized controlled trial with randomization at the level of the dental office. Dentists and dental hygienists from the greater San Francisco Bay Area were recruited to the study. The University of California at San Francisco Committee on Human Research approved the study and all

participants signed a consent form. Recruitment took place between April 2009 and September 2010 and follow-up occurred between May 2009 and February 2011.

Dentists and dental hygienists were eligible to participate if they performed scaling and root planing or teeth cleaning for more than 10 hours per week and had been doing this work for more than 1 year. They were not eligible if they were under a physician's care for treatment of an upper extremity disorder. Participants were recruited at local professional meetings.

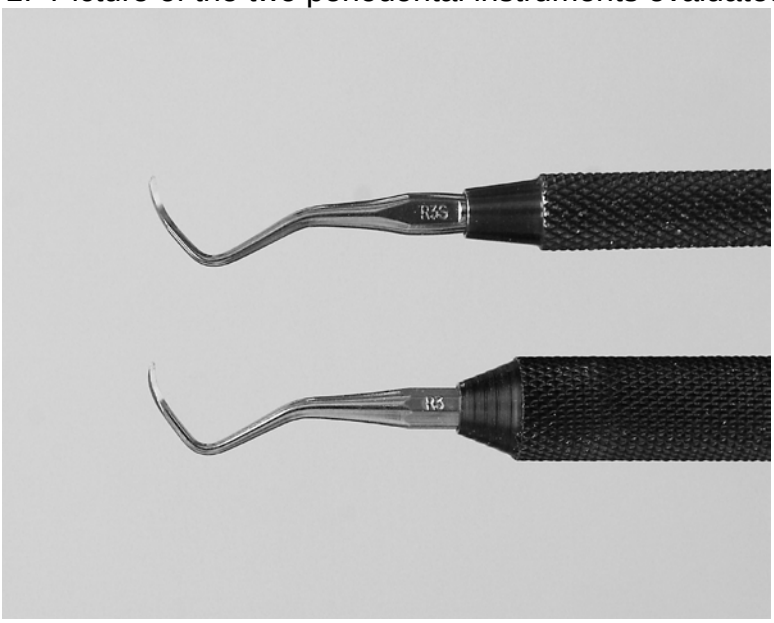
Participants completed an online baseline questionnaire that collected demographic data and work history. Participants then began completing an online questionnaire every week for the next 5 months. The weekly questionnaire, completed at the end of the workweek (e.g., Thursday or Friday), assessed maximum pain level (0 to 10 point scale with verbal anchors at 0 "No Pain" and 10 "Unbearable Pain") for right wrist/hand, right elbow/forearm, and right shoulder. The questionnaire also assessed hours performing different dental tasks during the week; number of nights woken from sleep with numbness in right thumb, index or middle finger; and number of days that pain medication was used for right upper extremity symptoms.

One month after starting the study, participants were randomly assigned one of two types of periodontal instruments for the remaining 4 months. Randomization was at the level of dental office. If two or more participants worked in the same office, they were assigned the same instrument to minimize contamination bias. Random assignments were computer generated by a postdoctoral fellow. Treatment allocation was concealed from the researchers who recruited participants. The one-month run-in period for the questionnaire, prior to the intervention, allowed participants to become accustomed to the questionnaire and provided baseline regional pain data. Participants were instructed to not discuss the study or their impressions of the assigned tools with other dental personnel inside or outside of their office.

Instrument 1 was 14 g (with curette tips) with an 11 mm diameter handle and instrument 2 was 34 g with an 8 mm diameter handle (Figure 1). The instrument diameters and weights were selected, based on prior laboratory studies (26), to provide a practical range that would have an effect on pinch force. The instruments were custom manufactured and surfaced with a medium diamond texture. Instrument 1 was made from black plastic (Polyoxymethylene (Delrin)) and instrument 2 was made from steel and plated black. All instruments were fitted with an R3S and an R4S tip (Ratcliff Stainless steel universal scalers, G. Hartzell & Son, Concord, CA). Participants were informed that the study involved evaluating a new periodontal instrument but did not know what design elements were being compared. They were, therefore, effectively blinded to the intervention. The cluster randomization, at the level of the dental office, also helped maintain blinding and minimized contamination. Participants received as

many of the instruments as they needed for their practice; the typical number requested ranged from 4 to 8. They were instructed to sterilize and sharpen the assigned instruments as they did their usual instruments. At the end of the study, participants completed an exit survey to assess their opinions about the instrument that they were assigned to use.

Figure 1. Picture of the two periodontal instruments evaluated in the study.



The primary outcomes tested were change in mean pain score, in the right wrist, elbow and shoulder, from the month prior to the intervention to the last month of the study adjusted for important covariates. Differences in pain score changes between the two treatment groups were compared using general linear models (SAS v10, Cary, NC) controlling for age, gender, occupation, and hours of instrument use per week. The analyses followed an intent-to-treat approach. The effect of interaction was tested between instrument and gender, instrument and age, and instrument and occupation. Sample size calculations were based on an estimated mean shoulder pain score of 2.9 (SD 1.6) (from preliminary studies). For a type I error of 5%, a total of 82 subjects (41 each group) were needed to have 80% power to detect a mean pain score change difference of 1.0 (33% difference in pain score change). To account for covariates and dropouts the recruitment goal was increased to 120. Ultimately, 120 subjects were recruited, but only 110 met the inclusion criteria. Secondary outcomes (i.e., nights waken from sleep with finger numbness, days of medication usage for pain) were compared using the student t-test for the subset of subjects who reported these outcomes.

Results

The 110 participants (13 dentists and 97 dental hygienists) worked at 90 different dental offices. The greatest number of participants in any one dental office was three. The mean age of the participants was 44.7 (±10.4) years and 100 were female. The similar distribution of demographic and other characteristics between the two treatment groups demonstrates baseline comparability (Table 1).

Table 1. Demographic and pre-intervention characteristics of the study participants (N=110).

	Heavy narrow handle (N=56)	Light wide handle (N=54)
	N/mean (SD)	N/mean (SD)
Age (years)	42.9 (10.8)	46.6 (9.8)
Gender		
Female	49	51
Male	7	3
Occupation		
Dentist	6	7
Dental hygienist	50	47
Years practicing		
1-5 years	16	7
>5 years	40	47
Dental scaling per week		
<20 h	14	14
20-30 h	19	20
>30 h	23	20
Percent time using hand scaler	62.5 (18.9)	65.7 (23.4)
Percent time using ultrasound scaler	39.8 (20.6)	37.5 (24.2)
Days per week doing dental work	3.7 (0.9)	3.6 (1.1)
Hours per day doing dental work	7.9 (0.7)	7.9 (0.8)
Patients treated in 8 h period	7.8 (1.8)	8.3 (1.2)
Second dental job	12	14
MD diagnosed upper extremity disorder[1]	8	10
In past month, pain, stiffness, ache in…		
Right shoulder	5	10
Right elbow/forearm	7	9
Right hand/wrist	15	12
Any difficult in past 4 months, due to upper extremity problem...		
using your usual technique for your work?	13	17
doing your usual work?	9	19
doing your work as well as you would like?	15	17
spending your usual amount of time doing	11	15

work?		
earning sufficient income?	5	4
Always or often physically exhausted after work	16	23
General health very good or excellent	42	45
Race/ethnicity		
Asian or Pacific Islander	8	15
Black, not of Hispanic Origin	1	2
Hispanic	8	3
White, not of Hispanic Origin	36	32
Other	3	2
Mean pre-intervention pain (0-10)		
Right shoulder	1.9 (1.3)	2.2 (1.5)
Right elbow/forearm	1.7 (1.3)	1.8 (1.3)
Right hand/wrist	1.9 (1.4)	2.3 (1.4)
Mean hours per week scaling or root planing[2]	10.7 (8.2)	11.3 (6.7)

[1] Wrist tendonitis, carpal tunnel syndrome, Raynaud's, epicondylitis, rotator cuff, cervical radiculopathy. Participants were not being treated for these at the time of the study.
[2] Calculated from reported scaling or root planing hours on weekly questionnaire during the 4-week pre-intervention period. Hours reported at baseline 'Dental scaling per week' are higher than those reported each week.

Five participants dropped out of the study between 2 and 12 weeks after receiving the intervention. Their data was included in the data analysis following intent-to-treat methods (e.g., the last observation was carried forward to the 16th week). One participant who was assigned the heavy, narrow diameter instrument dropped out because the instrument was too heavy. The other 4 dropouts were assigned the lighter, larger diameter instrument; one of these dropped out because the instrument was not as effective as her usual instruments and the other three stopped working due to personal health issues unrelated to the study. During the intervention period, the weekly reported mean hours of dental work, hours of scaling or root planing, and hours of use of assigned instrument per week were similar between treatment groups (Table 1).

The comparison of changes in pain scores between treatment groups, from the month before the intervention to the last month of the intervention period, is summarized in Table 2. The unadjusted pain scores improved more for subjects who used instrument 1 than instrument 2 for the 3 right upper extremity regions: wrist 0.50 v 0.14; elbow 0.20 v 0.06; and shoulder 0.51 v 0.19 (pain score improvement for instrument 1 v instrument 2). After adjusting for age, gender, occupation and hours of instrument use per week the differences due to instrument were only significant for the shoulder (0.52 v 0.19; p=0.02). The

interaction terms between instrument and gender, age, and occupation were non-significant and were therefore not included in the final models.

Table 2. Unadjusted and adjusted[1] regression models comparing the effects of instrument on change in pain scores in right upper extremity body regions.

	Heavy narrow handle (N=56)		Light wide handle (N=54)			
Right side	Mean pain change[2]	SEM	Mean pain change[2]	SEM	Beta[3] (95% CI)	p-value
Wrist/hand						
Unadjusted	0.14	0.11	0.40	0.11	0.13	0.10
Adjusted	0.14	0.17	0.40	0.18	0.11 (-0.04 - 0.28)	0.15
Elbow/forearm						
Unadjusted	0.06	0.09	0.20	0.09	0.07	0.27
Adjusted	0.06	0.14	0.20	0.15	0.07 (-0.06 - 0.21)	0.29
Shoulder						
Unadjusted	0.19	0.15	0.51	0.16	0.17	0.03
Adjusted	0.19	0.16	0.52	0.17	0.18 (0.02 - 0.324)	0.02

[1] Adjusted models include co-variates age, gender, occupation, and mean hours of instrument use per week.
[2] Positive values are the reduction in pain score over the intervention period.
[3] Beta coefficient for instrument in the general linear model.

For the secondary outcomes, both the number of nights waken from sleep with finger numbness and the number of days of pain medication usage improved more among those assigned the light, wide instruments compared to the heavy, narrow instruments (Table 3). The differences between groups in the change in the number of nights that the participants were waken from sleep with right thumb, index, or middle finger numbness was 1.53 (95% CI: 0.13 to 2.92; p=0.04). The difference between groups in change in days of pain medication usage was 0.74 (95% CI: -0.03 to 1.50; p=0.07).

Table 3. Secondary outcomes – summary measures on just participants who reported right finger numbness or those using medications for right upper extremity pain.

	Heavy narrow handle	Light wide handle	
	Mean (SD)	Mean (SD)	p-value
Mean nights per week waken from sleep due to numbness in fingers	(N=9)	(N=11)	
pre-intervention[1]	1.9 (2.1)	2.0 (2.3)	
post-intervention[1]	2.1 (2.7)	0.7 (1.1)	
pre-post change[2]	-0.3 (1.0)	1.3 (1.9)	0.04
Mean number of days using medications for upper extremity pain	(N=13)	(N=15)	
pre-intervention[1]	1.5 (2.2)	1.1 (1.4)	
post-intervention[1]	1.7 (2.7)	0.6 (1.0)	
pre-post change[2]	-0.2 (1.3)	0.5 (0.7)	0.07

[1] Calculated from weekly questionnaire during the 4-week pre-intervention period.
[2] Mean pre-intervention minus mean post-intervention. Positive values indicate a reduction in finger numbness or medication usage after the intervention.

The exit survey ratings for instrument diameter, weight, shape, and productivity were more positive for participants who used the light, large diameter handle than the heavy, narrow handle (Table 4). Similar findings were noted after summing their responses to the open-ended questions on the positive and negative features of the assigned instrument. The assigned instruments were used approximately 82% of the time during scaling and root planning. An indication of successful blinding was that the positive and negative comments on the handle texture, which was the same for the two instruments, were similarly distributed between the intervention groups. Some participants who used the larger diameter lighter instruments reported that the tips were easily loosened and not stiff enough. These instruments were made from Delrin, which did not maintain a stiff thread; therefore, several of these handles had to be replaced during the study.

Table 4. Work pattern during the intervention period and exit survey results.

	Heavy narrow handle (N=56)	Light wide handle (N=54)
	Mean (SD)/N	Mean (SD)/N
Mean hours per week of…[1]		
dental work	25.3 (7.3)	25.3 (7.6)
scaling or root planing	12.4 (7.8)	11.9 (6.4)
use of new instrument	9.8 (4.8)	10.2 (6.4)
Exit: rating of new instrument (0=Worst; 5=Best)		
compared to old	2.6 (1.3)	3.6 (1.4)
diameter	2.4 (1.2)	3.9 (1.1)
weight	2.3 (1.5)	4.3 (1.1)
shape	2.8 (1.2)	3.9 (1.0)
productivity	2.7 (1.1)	3.6 (1.3)
Exit: positive features of new instrument [2]		
weight	10	38
diameter	9	19
surface texture	13	9
Exit: negative features of new instrument [2]		
weight	28	4
diameter	22	1
surface texture	4	3
tips too loose	3	16

[1] Calculated from the weekly questionnaire during the intervention period.
[2] Cumulative responses from open ended questions on exit survey.

Discussion

The mean pain score changes for the three right arm regions improved in both treatment groups during the 4-month intervention. However, the scores improved more among those who were assigned the lighter, larger diameter handle curette than those who were assigned the heavier, small diameter handle instrument. The differences between groups were significant for change in shoulder pain but not for change in wrist or elbow pain. The lack of interactions between instrument and the co-variates indicate that the observed changes in pain are relatively homogeneous across the range of the covariates and that stratification on the covariates would not alter the findings.

The observed difference between groups in right shoulder pain change was modest, 0.33, and represents a 16% decline from the mean baseline right shoulder pain score of 2.1. While the effect is relatively small, it is similar to that observed in other workplace intervention studies. New chair designs tested in garment workers reduced shoulder/neck pain by 0.28 or 0.68 (28) and a forearm support board reduced shoulder/neck pain among computer users by 0.48 on the

same 0 to 10 scale (29). Based on our previous laboratory studies, we expected more than a 33% reduction in pinch force when subjects used the lighter, larger diameter instrument compared to the heavier, smaller diameter instrument. A recent prospective study of blue-collar workers found that the duration of work with pinch force greater than 10N was a strong predictor for upper extremity musculoskeletal disorders (19). The smaller effect size observed in this RCT may be due to fact that the participants actually use more instruments than the ones provided by the researchers when doing dental hygiene work. A larger effect might have been observed if most of the instruments used were replaced with ones with lightweight, larger handles.

The effect of instrument and differences in pinch force on the shoulder may be due to an increase in shoulder muscle co-contraction when the hand grip force is increased (30). During dental hygiene work, the high force, fine motor work of the hand requires shoulder stabilization, which is achieved by increased shoulder muscle activity. Epidemiologic studies have identified forceful pinch as a risk factor for shoulder disorders (24,25).

Secondary outcome measures also improved more among those assigned the light, wide diameter curettes compared to those assigned the narrow heavy curettes. At baseline, approximately 18% of subjects reported symptoms, which may be associated with carpal tunnel syndrome (e.g., numbness or tingling in the thumb, index or middle finger), and reported waking an average of 2 nights per week with their symptoms. Among those assigned the light, wide curette, this dropped to 0.7 nights per week while in the other group it dropped to 1.6 nights per week ($p=0.04$). There was no adjustment for covariates in the analysis given the small number of subjects. There was no significant difference in change in medication usage between the treatment groups.

The strengths of the study were the randomized intervention design with randomization at the level of the dental office to minimize contamination and maintain blinding; the subject blinding to the specific features of the instrument being evaluated; the allocation concealment; the effective randomization of participants with similar demographic characteristics of the treatment groups; the study sample size; the low drop-out rate; the similar hours per week of dental work and exposure to the intervention instruments between treatment groups; and the intention to treat approach to analysis. A limitation of the study was restricting the testing of handle change to only one instrument in the participants' dental armamentarium. Another limitation was the lack of objective clinical outcome measures with physical examinations or nerve conduction studies of participants. However, adding clinical outcomes would have significantly increased the study expense and the more complex logistics may have reduced the number of participants.

In conclusion, the replacement of periodontal instruments with handles that are lighter and larger in diameter (11 mm) than a typical handle is likely to be a low

cost intervention for providing a modest reduction in arm pain among dental practitioners who do dental hygiene work. Other workplace changes are also likely to reduce arm pain but these interventions have not been evaluated in RCTs. These changes include maintaining sharp scaling tips in order to reduce the applied pinch force; scheduling patients with heavy calculus on different days; and reducing the time that a high pinch force is applied during the workday (e.g., adequate recovery time from pinch). Other handle designs, such as a tapered grip or high friction surface, may also reduce applied pinch force during dental hygiene work, but these have also not been tested in field studies.

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Inclusion of gender and minority study subjects:

Inclusion Enrollment Report

Study Title: Effect of Tool Design on Hand Pain in Dental Practitioners

Total Enrollment: 110 **Protocol Number:**

Grant Number: OH008892

PART A. TOTAL ENROLLMENT REPORT: Number of Subjects Enrolled to Date (Cumulative)				
Ethnic Category	**Females**	**Males**	**Sex/Gender Unknown**	**Total**
Hispanic or Latino				11 **
Not Hispanic or Latino				94
Unknown (individuals not reporting ethnicity)				5
Ethnic Category: Total of All Subjects*	100	10	0	110 *
Racial Categories				
American Indian/Alaska Native				0
Asian or Pacific Islander				23
Black, not of Hispanic Origin				3
White, not of Hispanic Origin				68
Hispanic or Latino				11
Other or Not Reported				5
Racial Categories: Total of All Subjects*	100	10	0	110 *

* These totals must agree.
** These totals must agree.

Inclusion of Children

There were no children (ages of 18 and 21) in the study.

Publications

Journal Articles

Rempel D, Lee D, Dawson K, Loomer P. Effect of periodontal curette handle weight and diameter on dental practitioner arm pain: A 4-month randomized controlled trial. J Am Dental Assoc. 2012 (in press).

Proceedings

Rempel D, Lee D, Dawson K, Loomer P. Effect of tool handle design among dental practitioners: a randomized controlled trial. International Congress on Occupational Health 2012. Mexico.

Rempel D, Lee D, Dawson K, Loomer P. Effect of tool handle design among dental practitioners: a randomized controlled trial. International Ergonomics Association 2012. Recife, Brazil

Loomer P, Lee D, Rempel D. Periodontal curette handle design affects upper extremity pain: A 4 month randomized controlled trial. Annual meeting of American Academy of Periodontology, Nov 12, 2011.