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Get a Grip: How Hand Anthropometrics, Grip Strength, and Sex Influence Power Tool Use in Orthopaedics

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Introduction: Female surgeons typically have smaller hands, report negative perceptions, and experience pain and discomfort related to instrument design. The aims of this study were to determine whether orthopaedic surgeons receive teaching on power-tool handling, identify power-tool grips used, evaluate whether grip strength and hand anthropometrics influence grip choice, and examine the impact of sex on power tool perceptions.

Methods: Orthopaedic surgeons (residents and attendings) were surveyed on their power tool perceptions and teaching methods. An objective assessment was carried out which included the categorization of power tool grips, measurement of grip strength, and anthropometric measurements of the hand.

Results: Forty-six orthopaedic surgeons (12 female, 34 male) were recruited with a response rate of 96%. No orthopaedic surgeon reported formal teaching on power tool handling. Female surgeons reported more negative experiences using the wire driver and drill. Participants demonstrated 2 variations in power tool posture, with an equal split, determined by the index finger position on either the top or bottom trigger. The index finger bottom position was associated with reduced grip strength, female sex, and smaller hand and palm length compared with the index finger top position.

Conclusion: Surgeons with smaller hands or lower grip strength, particularly females, were more likely to use an index finger supported grip, likely as a compensatory strategy. There is the need for early training in power-tool ergonomics and grip techniques, as well as grip strengthening initiatives. The current one-size-fits-all approach is inadequate; manufacturers should ensure designs accommodate a wide range of hand sizes, accounting for palm length and overall hand length, to accommodate all users.

Introduction

It is estimated 15 to 26% of orthopaedic surgeons in North America and UK training programs are female, and this number continues to rise with an increasingly diverse workforce[1-4]. Female surgeons typically have smaller hand sizes, and report negative perceptions as well as experiencing pain and discomfort related to instrument design; these issues have been frequently described in general surgery[5,6].

A drill and wire driver are arguably 2 of the most important tools used within modern orthopaedic surgery; however, when

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surveyed, resident orthopaedic surgeons with small hands reported having difficulty using a wire driver[7]. Furthermore, in simulated laparoscopic general surgery, it has been shown that appropriately sized instrument handles can improve surgical performance[8]. In orthopaedic power tool design, a one-size-fits-all approach remains standard practice, although smaller designed power does exist in extremity surgery.

This is the first study that combines orthopaedic surgeons' power tool grips, perceptions, grip strength, and anthropometric data. This provides valuable information to industry when considering power tool design and identifies topics that should be incorporated into orthopaedic training and education. As the orthopaedic workforce continues to diversify, it is important to understand these challenges that are encountered, so solutions can be developed to overcome them.

The aims of this descriptive epidemiological study were to describe training in power-tool handling among orthopaedic surgeons, characterize power-tool grips used in clinical practice, and describe patterns of grip choice in relation to grip strength and hand anthropometry. This is in conjunction with a qualitative study to explore the perceived impact of sex on power-tool use and perceptions.

Methods

Study Design

This study recruited orthopaedic surgeons (residents and/or attendings) across 2 regional teaching days (educational days comprising lectures and practical workshops, held for orthopaedic residents, delivered by orthopaedic attendings). Those who had registered for the teaching day or were faculty were sent participant information through email. On the day, written consent was obtained and data were pseudoanonymized with a participant ID linking the different parts of the study. Ethical approval was obtained from the Research Governance and Integrity team at the host institution. If participants were not fit to operate due to illness or injury at the time of data collection, they were excluded.

The initial part of the study was a subjective assessment, a survey examining perceptions of power tools in practice and teaching methods, and an objective assessment of power tool handling, grip strength, and hand size.

Electronic Survey

An electronic survey was developed following consultation with industry experts and orthopaedic surgeons; it was tested on a pilot group of 7 orthopaedic surgeons (3 female, 4 male). Feedback and discussion between the pilot participants and the research team brought refinement of question wording, removal of ambiguous items, and improvement of overall usability. Following this, "straining" was defined as experiencing discomfort, pain, fatigue, or stiffness in 1 or more fingers during or after the task.

The survey was reported in accordance with the Checklist for Reporting Results of Internet E-Surveys guidelines for web-based surveys[9]. The survey was completed using Qualtrics. Demographic data including sex, age, hand dominance, and glove size were collected. Participants then answered questions on perceptions of drill and wire driver design and teaching methods. Responses were measured using a 5-point Likert scale, with response anchors adapted to match the wording of each question.

Handling a Power Tool

Participants were asked to pick up an orthopaedic drill (battery powered, cordless) and wire driver (Traumadrive, De Soutter Medical Ltd) in the manner they would use in the operating theater. Their grip was photographed and categorized in relation to the position of the index finger. For the wire driver, the number of fingers around the wire driver was also recorded. The wire driver was connected to the same handpiece as the drill with the same dimensions (hand length and battery weight) and torque. The center of mass of both devices lies within the hand piece. The grip categories were "index finger top" and "index finger bottom" and were chosen as the index finger commonly controls the trigger[10]. The top trigger was reverse, and the bottom trigger was forward; these could not be customized. The positions are described in the results and are as shown in Figures 1 and 2.

Grip Strength

Grip strength was assessed following the clinical guidelines of the American Society of Hand Therapists[11]. Grip strength was measured using an electronic handgrip dynamometer (Biometrics Ltd. Fig. 3). Measurements were taken from the dominant hand. The maximum value from 3 trials was recorded in keeping with published protocols[12].

Anthropometric Measurements

Photographs were taken of the dorsal aspect of the dominant hand of each participant against a background containing registration marks. Photographs were taken with an open and closed span. Landmarks on the hand were digitized on the electronic images, and hand span, palm length, and hand length were calculated using MATLAB (The Mathworks USA)[13].

Statistical Analysis

Given the descriptive epidemiological nature of the study, all analyses were conducted as post hoc exploratory analyses. The survey response rate was determined by dividing the number of participants who completed the study by the total number of attendees at the teaching day. Responses from the survey are reported descriptively. Demographic data are presented in frequencies and percentages if categorical. If continuous, data are reported as means and standard deviations or medians and ranges, depending on the spread. A Shapiro-Wilk test was carried out to determine this. Associations between sex and demographic data were analyzed using the Mann-Whitney U test for continuous variables and the χ^2 test for categorical variables.

The dynamometric and anthropometric data are presented descriptively. A subgroup analysis comparing dynamometric and anthropometric data according to grip posture

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Fig. 1

The 2 different grips with which the participants held the drill: with the index finger on the top trigger position (left) and the index finger on the bottom trigger position (right).

for both the drill and the wire driver was completed using an unpaired t-test. Grip posture and categorical data, including gender and reported perceptions, were analyzed using a χ^2 test. Statistical significant was set at $p < 0.05$. Statistical analysis was completed using Microsoft Excel (Version 365; Microsoft Corporation, 2025).



Fig. 2

Four grips used to hold the wire driver: (A) index finger on the top trigger, 3 fingers on the wire driver; (B) index finger on the top trigger, 2 fingers on the wire driver; (C) index finger on the bottom trigger, 3 fingers on the wire driver; (D) index finger on the bottom trigger, 2 fingers on the wire driver.

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Fig. 3

Participant position for grip strength measurements; the shoulders remained in a neutral position, the elbow was flexed at 90°, the forearm was in a mid-prone position, and the wrist was extended between 0° and 30°. The back was kept straight and supported by the chair's backrest.

Results

The demographic data of the study participants are presented in Table I; all participants partook in both the subjective and objective assessments. There was a study response and completion rate of 96% (46/48).

Electronic Survey

No participants reported receiving formal teaching on how to use a power tool, half of the participants (23/46) reported receiving informal teaching in theater, whilst the other half reported they had received no teaching (informal or formal).

Thirty-seven (37/46) participants reported their grip either "rarely" or "never" slipped when drilling, 5 of these were female (5/37). The remaining participants (9/46) reported it occurred "frequently" or "occasionally," including 7 females (7/9).

Twenty-three (23/46) participants reported they "rarely" or "never" strained their fingers when using a wire driver, including 1 female. Sixteen (16/46) reported straining their fingers "occasionally", including 5 females (5/16). Seven (7/46) reported straining "frequently" or "very frequently", including 6 females (6/7).

Twenty-eight (28/46) participants perceived the weight of the drill to be "appropriate", including 1 female. The remaining 18 participants (18/46) perceived it to be either "heavy" or "very heavy", including 11 females. Thirty-four (34/46) participants perceived the handle size as "appropriate," including 2 females. The remaining 12 (12/46) participants perceived the handle size as "big," including 10 females (10/12).

Handling a Power Tool

When asked to pick up a drill, half of the participants (23/46) held their index finger on the top trigger, whilst the remaining half held their index finger on the bottom trigger (Fig. 2). There was a difference ($p = 0.04$) in gender and index finger position, with females more likely to have their index finger at the bottom (female 9/12 vs. male 14/34).

In the survey data, 9 of the 12 participants who perceived the handle size as "big" had their index finger on the bottom trigger ($p = 0.04$). There was no difference in drill weight perception and finger position.

When asked to pick up a wire driver, half (23/46) held their index finger on the top trigger, whilst the remaining half (23/46) held on the bottom trigger. Of the 23 who held the bottom, 22 participants had 3 fingers around the wire driver (c), whilst 1 participant had 2 fingers around the wire driver (d). Of the 23 who held their index finger on the top, 16 participants had 2 fingers around the wire driver (b), whilst 7 had 3 fingers around it (a). The different grips are displayed in Figure 2.

Six participants (13%) did not use consistent grip postures for both placed the wire driver and drill (e.g. index finger top—drill, index finger bottom—wire driver). Eight of 12 females (vs. 15/34 males) adopted the index finger bottom position when holding the wire driver ($p = 0.18$).

Grip Strength

The mean grip strength for females (32.9 ± 3.2 kg) was less ($p < 0.0001$) when compared with males (53.4 ± 9.8 kg) (Table II). There was a 14.8 kg difference in the maximum grip strength between those who positioned their index finger on the top trigger and those who positioned their index finger on the bottom trigger when holding the drill. This was seen also with the wire driver (9.9 kg difference) (Table II).

Anthropometric Measurements

Anthropometric measurement results are displayed in Table II. Females had a smaller hand span, palm length, and hand length compared with males ($p < 0.0001$). Those who held the drill with their index finger on the bottom trigger also had smaller palm ($p = 0.02$) and hand ($p = 0.04$) lengths than those who held the drill with their index finger on the top trigger.

Discussion

The survey results showed that no formal training had been received on how to hold a power tool. Power tools are a huge part of orthopaedic surgery and essential for sawing, reaming, drilling, and insertion of wires into the bone[14]. A recent study demonstrated that surgeons who received ergonomic training and exercise programs showed improvement

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TABLE I Demographics of the Study Sample, Overall, and Stratified by Sex

Demographic	Female	Male	All	p
Sex (%)	12 (26.09)	34 (73.91)	46	—
Median age (IQR)	32 (30-34)	34 (31-38)	34 (31-38)	0.13
Seniority				
Resident	10	26	34 (73.91)	0.44
Attending	2	10	12 (26/09)	
Median glove size (range)	6.5 (5.5-7)	8 (7-8.5)	7.5 (5.5-8.5)	p < 0.001
Hand dominance				
Right	11	32	41 (89.3)	0.77
Left	1	2	3 (6.52)	
Ambidextrous	0	2	2 (4.35)	

IQR = interquartile range.

in pain, physical workload, mental health, and quality-of-life measurements[15]. It is important that at the start of training, surgeons are educated on grip ergonomics and are able to experiment with different grips in a simulated setting. Similar to sports such as golf and tennis, it is difficult to change a preexisting grip after many years, even if it is not the most ergonomic[16]. Unergonomic grips could place the surgeon at increased risk of occupational injury[17]. Incorporating ergonomic education into surgical residency curricula could help address this risk.

Females are more likely to experience difficulties with their grip, slipping when drilling and straining of their fingers when using a wire driver. This is in keeping with the literature from laparoscopic general surgery and survey findings from orthopaedic residents in the United States[7,18].

In line with our anthropometric data, this difference is likely explained by females having smaller hand spans and shorter hand and palm lengths compared with males. This, in combination with lower grip strength, likely makes it more difficult to grip a power tool. The distance from the outside of the power tool, where the thumb sits, to where the fingers grasp the wire driver is smaller, potentially causing greater strain through the fingers. Our survey data demonstrated females were more likely to report straining their fingers "frequently" or "very frequently" compared with males.

Our data demonstrated that 2 different hand postures were used when holding the power tool, with an equal divide between the 2 hand postures. There was a trend in participant grip strength and position of the index finger for both the drill and the wire driver. Those who had their index finger on the bottom trigger had reduced grip strength compared with those who had it on the top trigger. This has not been reported previously in the literature, but 1 explanation is that the index finger bottom position could be an adaptation for those with lower grip strength to compensate for the ergonomic mismatch with the power tool. This is an important design consideration for the surgical power tool industry, as it demonstrates one size does not fit all. Those who adopt the posture with their index finger on the bottom

TABLE II Grip Strength and Anthropometric Data for All Participants, Including a Subgroup Analysis for Grip Position for the Drill and Wire Driver

	Grip Strength (kg)	p	Hand Span (mm)	p	Palm Length (mm)	p	Hand Length (mm)	p
All								
Female	32.9 ± 3.2	p < 0.001	171.5 ± 16.2	p < 0.001	116.7 ± 7.2	p < 0.001	188.9 ± 13.5	p < 0.001
Male	53.4 ± 9.8		202.0 ± 7.8		127.7 ± 7.8		217.0 ± 10.5	
Drill								
Index finger top	55.5 ± 10.8	p < 0.001	196.5 ± 24.9	p = 0.57	127.8 ± 8.3	p = 0.02	214.7 ± 13.9	p = 0.04
Index finger bottom	40.7 ± 9.4		191.6 ± 24.5		121.8 ± 8.8		204.6 ± 18.0	
Wire driver								
Index finger top	53.0 ± 12.8	p = 0.006	196.1 ± 27.2	p = 0.57	126.5 ± 9.9	p = 0.21	211.8 ± 17.3	p = 0.39
Index finger bottom	43.1 ± 10.42		192.0 ± 21.9		123.2 ± 7.9		207.5 ± 16.2	

Presented as mean ± 1 SD.

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trigger may benefit from grip strengthening programs, which have been described in the literature[19]. However, it is unknown if grip strengthening programs can compensate for the smaller hand span, which was also noted with the index finger bottom grip. This grip may be a natural response to improve mechanical advantage and keep the hand in a closed grip posture rather than due to a difference in grip strength.

A study on 135 laparoscopic surgeons in Spain used 3D printing to design a handle that was scalable to all hand sizes based on anthropometric measurements[20]. They reported that palm length was the most important measurement that allowed the 3D handle to be conveniently scaled. Our data demonstrated that a smaller hand and palm length was associated with an index finger bottom position adaptive grip. Orthopaedic power tools should be designed to accommodate a wide range of hand sizes taking into account palm and hand length, ensuring usability for all users.

An important limitation to consider is the role of sex in self-reporting. It has been shown that males are less likely to self-report challenges than females[21]. Therefore, male negative perceptions may be underreported in this group. We did not investigate whether the self-reported challenges influenced surgical performance. It has been shown in obstetrics and gynecology and plastic surgery that female residents underrate their surgical skills, but perform at least equivalently to their male counterparts[22,23]. Another limitation is the small sample size. However, this study included both objective and subjective measures, as opposed to only survey data. Owing to the sample size, a descriptive epidemiological approach was adopted which precluded formal hypothesis testing. We believe the high response rate reduces the risk of selection bias, but nevertheless the risk does remain due to convenience sampling. We used anthropometric measurements as opposed to surgical glove group data, as these quantitative data allow us to detect differences that glove groupings may miss.

Conclusion

Female surgeons reported more negative experiences using both the wire driver and the drill. Two main grip styles emerged, influenced by sex, grip strength, and hand size. Surgeons with smaller hands or lower grip strength, particularly females, were more likely to use an index finger-supported grip, likely as a compensatory strategy.

These findings highlight the need for early training in power-tool ergonomics and grip technique in orthopaedic education, as well as grip-strengthening initiatives. Current "one-size-fits-all" power tools are inadequate; manufacturers should consider variations in handle size, especially accounting for palm length and overall hand length, to better accommodate all users. ■

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