

Resolution of Thumb Pain following Adoption of Mathieu Needle Holder: An Ergonomic Analysis

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Background: As surveys reveal the prevalence of musculoskeletal pain among surgeons, it is important to have an appreciation and understanding of surgical ergonomics to protect against long-term injuries and mitigate the symptoms of existing conditions. Surgeons diagnosed with thumb carpometacarpal (CMC) joint osteoarthritis, a progressive and debilitating condition, can be especially vulnerable to the pain caused by the repetitive manual tasks of operating.

Methods: In this article, the authors describe a case of occupational thumb CMC arthritis in a right-hand dominant plastic surgeon and provide an ergonomic analysis of the different needle holders.

Results: Following diagnosis, the simple switch from the traditional Hegar needle holder to the Mathieu needle driver with its palm grip and rotating ratchet lock mechanism stalled the progression of the disease, allowing the surgeon to continue operating pain free.

Conclusions: This is the first report of utilization of an alternative needle holder leading to the resolution of thumb pain. In sharing this case, the authors hope to bring awareness to the importance of hand ergonomics in the operating room and offer a practical tip to surgeons with CMC arthritis. (*Plast Reconstr Surg Glob Open* 2020;8:e2768; doi: [10.1097/GOX.0000000000002768](https://doi.org/10.1097/GOX.0000000000002768); Published online 24 April 2020.)

INTRODUCTION

Thumb carpometacarpal (CMC) joint osteoarthritis is a progressive and debilitating condition that eventually results in joint instability, subluxation, and pantrapezial arthritis in a subset of patients.¹ It is a common diagnosis, affecting approximately 8% of men and 25% of women over the age of 50 years in the United States and is increasing in prevalence due to the aging population.² Although the exact incidence among physicians is not known, the development of thumb CMC arthritis is known to be associated with repetitive manual tasks, as are performed daily by surgeons.¹ Up to 20% of patients affected by thumb CMC arthritis undergo nonoperative or surgical treatments.² Although these are typically effective, the average time out of work after soft-tissue arthroplasty was >120 days in one study, which would be extremely disruptive to a surgeon's practice, if not career ending.³ We report a case of occupational thumb CMC

arthritis in a plastic surgeon in which implementation of a Mathieu needle holder led to complete resolution of symptoms. We present comparisons in hand ergonomics between the standard needle holder and the Mathieu needle holder. Our goal is to suggest an alternative to the standard needle driver that may alleviate basilar thumb pain in surgeons with early thumb CMC arthritis, increase quality of life, and potentially prolong their career.

CASE REPORT

After years of operating, a right-hand dominant female plastic surgeon began experiencing discomfort and pain in the right thumb. Although initially periodic while suturing, this discomfort eventually became constant and was exacerbated by even minor movements, such as small injections. The surgeon was seen by a hand specialist in 2011 and diagnosed with mild CMC arthritis. The physical examination was significant for moderate CMC joint tenderness and a negative grind test. Radiographic imaging of the right thumb showed small marginal osteophyte formation consistent with Eaton and Littler Stage II CMC arthritis (Fig. 1). Given that the patient was moderately symptomatic, the treatment plan consisted primarily of

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Fig. 1. Radiographic imaging of the right thumb showing small marginal osteophyte formation consistent with Eaton and Littler Stage II CMC arthritis.

splinting and anti-inflammatory medication. Pain and discomfort persisted despite conservative management and the surgeon reported concern with continued practice if symptoms continued to worsen. The surgeon was eventually introduced to the Mathieu needle holder by a colleague with an oral surgery background. Consistent use of the Mathieu needle holder instead of the traditional Hegar needle holder while operating quickly led to symptom improvement and, eventually, full resolution of right thumb basilar joint pain. Continued and ongoing use of the Mathieu needle holder since 2011, including different grip sizes for different needle caliber and surgical application, has resulted in a consistently pain-free state.

ERGONOMIC ANALYSIS

The traditional Hegar or Webster needle holder has ring-shaped handles with a linear ratchet locking mechanism located between the rings (Fig. 2A). In the typical finger grip, the thumb and ring fingers are inserted into the rings for needle driver control. The needle driver movements of grasping, locking, and releasing the needle can all be accomplished with finger grip, which results in significant motion primarily focused at the CMC joint of the thumb. (See Video 1 [online], which displays live fluoroscopy of the Hegar needle holder in use, demonstrating significant movement of the CMC joint.) In addition to this finger grip, the conventional needle driver also uses palmar grip, where it is grasped between the thenar eminence and the proximal phalanges of the most ulnar 2 fingers. With this grip, the thumb and index finger typically stabilize the arm without being fully inserted into the ring. The palmar grip results in mainly metacarpophalangeal (MP) and interphalangeal (IP) motion and less CMC motion on dynamic fluoroscopy. The major advantages of this grip

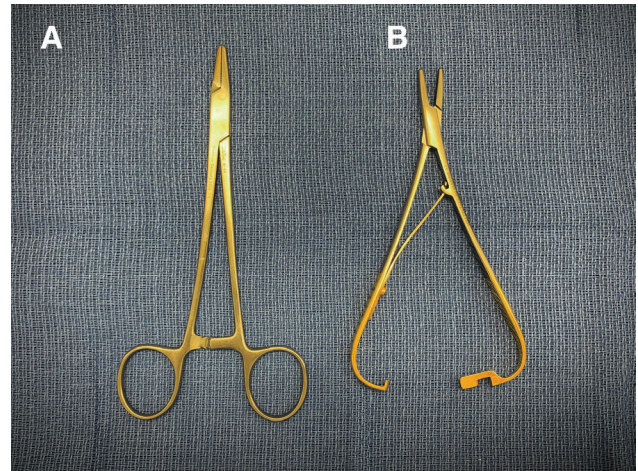


Fig. 2. Comparison of needle holders. A, The traditional Hegar or Webster needle holder. B, The Mathieu needle holder.

are increased versatility and the possibility of applying controlled force with small movements, but the palmar grip may not be the best option for all surgeons, particularly those with smaller hands relative to the common instruments available. The majority of surgeons use all these grips for suturing and typically start with a finger grip and then switch to the palmar grip to place the stitch. Once the needle is inserted into tissue, the needle may be released in any grip; this requires the application of inward pressure by the thumb with simultaneous abduction so that the ratchets of the 2 handles disengage and pass each other.⁴ Full release of the needle is accomplished by further excursion of the thumb ring/arm (with motion centered about the CMC joint) against the mostly stable ring finger handle/arm. After analysis of the hand/thumb mechanics involved with the use of the traditional Hegar needle holder, it is not surprising that years of this repetitive motion and stress may lead to or exacerbate thumb CMC osteoarthritis and pain.

The Mathieu needle holder was invented by Louis-Joseph Mathieu (1817–1879), a Belgian-born surgical cutler who established a prestigious cutlery workshop in Paris in 1848, which was passed successfully on to his 2 sons.⁵ The Mathieu needle holder can be found advertised in Mathieu's French catalogues of surgical instruments in the mid-19th century.⁶ It is similar in shape to that of the Castroviejo needle holder, which most plastic surgeons will be familiar with, but is capable of being used with larger needles. The Mathieu needle holder does not have thumb and finger ring handles and is designed with the ratchet lock at the end of the inwardly curved arms (Fig. 2B). A spring between the 2 arms facilitates its opening once the ratchet is released. Unlike the standard needle holder, the Mathieu needle driver only has one grip, and it is held in the palm, with one arm handle against the proximal phalanx and thenar eminence of the thumb and the other arm against the proximal and middle phalanges of the ulnar 4 fingers. It is opened by squeezing the 2 arms of the needle holder together, mainly using flexion of the MCPs and PIPs of the ulnar 4 digits against the stable base of the thenar eminence, with much less motion at the thumb CMC and

MP joints. (See Video 2 [online], which displays live fluoroscopy of the Mathieu needle holder in use, demonstrating reduced motion at the CMC joint.) The ratchet mechanism of the Mathieu needle driver is designed to rotate, which allows the needle holder to open after passing the last ratchet. Thus, the surgeon unlocks the driver by simply compressing the 2 arms closer together and allowing the needle driver jaws to open, assisted by the outward pressure produced by the spring mechanism. Therefore, unlike the traditional Hegar needle holder, the arms of the Mathieu move equally in grasping and releasing the needle, which produces less overall movement at the thumb CMC joint as observed in the video analysis of the 2 needle holders.

DISCUSSION

Ergonomics, defined as the triple aim of optimizing performance, decreasing errors, and preventing injury, are relevant to any occupation that uses tools to accomplish the job. Historically, there has been a lack of investigation into surgical ergonomics for several complex reasons, including, but not limited to, surgeons' desire to avoid oversight by outside parties as well as training in an environment and culture that discourages the reporting of stress and fatigue.⁷ Recent developments within the last several decades have brought surgical ergonomics to the forefront of discussion within national surgical societies and regulatory agencies.^{8,9} First and foremost, the workload placed on surgeons is greater than ever, with the same number of surgeons today as in 1995 treating a population that has increased from 263 to 330 million over the same time period.¹⁰ In addition, the Food and Drug Administration has recognized the importance of instrumentation because it has been estimated that half of unintentional patient injuries can be accounted for by poor surgical instrument design.¹¹ Furthermore, the advent of laparoscopic and minimally invasive surgery, along with the rapid expansion of technology in all surgical disciplines, have led to increased reports of musculoskeletal complaints associated with the changing working conditions (eg, use of a video monitor; awkward hand/arm movements, poor posture). In the context of an impending workforce shortage of surgeons, with increasing disability associated with poor ergonomics, this has been described as an "ergonomic crisis" in surgery.^{10,11}

Multiple surveys have documented the significant and increasing rates of work-related musculoskeletal pain/disorder in several surgical subspecialties. Up to 87% of surgeons report significant work-related musculoskeletal pain while operating, with 9.2% of all surgeons eventually forced into retirement by a work-related musculoskeletal disorder.^{8,12-16} One study of oncologic surgeons documented that 27% of surgeons reported an occupational injury, with nearly 1 in 5 of these requiring surgical treatment.¹⁴ A symptom-based survey of British consultant surgeons found that 80% reported pain while operating, with the hand being the second most common site of pain following the back and neck.¹⁷ Surprisingly, 65% of these surgeons never sought assistance despite musculoskeletal pain.¹⁷ The occupational demands of surgery are not lost

on trainees, as nearly one third of medical students cited "physical demands" as the main deterrent to their interest in the surgical field.¹⁸ Within plastic and reconstructive surgery, 78%–82% of plastic surgeons in the United States, Canada, and Norway have reported experiencing work-related musculoskeletal symptoms.^{9,19-21} The most common conditions reported were muscle strain, vision changes, cervical pain, lumbar pain, and shoulder arthritis/bursitis. Thumb arthritis was reported more commonly among hand surgeons, and, overall, 6.7% of plastic surgeons required surgical intervention for their symptoms.^{19,20}

Hand pain can be attributed in large part to the repetitive use of surgical instruments and a mismatch between the intent of the design and the needs of the user. It has been recognized that mass-produced instruments have been primarily designed for surgeons who are taller and in general possess larger and stronger hands.^{22,23} A study of laparoscopic general surgeons identified that a similar proportion of male and female surgeons (>80%) indicated physical discomfort related to operating.²³ However, female surgeons were more likely to receive treatment for their wrist, thumb, and finger conditions. These differences persisted when controlling for glove size. The authors conclude that female surgeons experience clinically significant hand-related complaints at a higher-rate compared with their male colleagues and propose changes in laparoscopic instrument design and table height.²³ Their work joins many others in seeking to optimize the ergonomics of laparoscopic instrument handles for all surgeons.²⁴⁻²⁷

Although there have been important advances in the ergonomics of laparoscopic surgery and optimal conditions for the minimally invasive OR suite, there remain few studies on the ergonomics of open surgical instrumentation.⁷ Surgical instruments were designed in large part for universality and ease of use, mass production, and rapid sterilization. These constraints are not often compatible with the individual variations that may be necessary to optimize individual surgeon performance and comfort.⁷ There have been detailed analyses of surgeons' power and precision grip,²⁸ technical descriptions of needle holder movement in restricted operating spaces,²⁹ testing of different surgical needles and holders to pair instrument with application,³⁰ and comparisons of surgical efficiency between needle holder designs,^{4,31} but no reports relating design of needle holders or other instruments used in open surgery to development or treatment of clinical symptoms in surgeons.

Apart from more statically held instruments such as forceps, or those with minimal movements like scissors, needle drivers are dynamic instruments that require significant hand motion for use. Although the movements are complex, the components of a needle driver are relatively simple: the needle jaws, the joint, the arms, and the distal handles. Most needle holders also have a ratchet lock mechanism to lock the needle in place while manipulating it through tissue. Variations in the design/shape of the arms, handles, and ratchet mechanism represent most of the differences between commonly utilized needle drivers and may result in significant changes in joint motion of a surgeon's hand. Although it may not be practical to manufacture custom instruments for individual surgeons

on a large scale, the significant variation in design already present in the marketplace presents an opportunity for assessment and comparison of ergonomics between instruments to optimize surgical performance and decrease occupational injury.

CONCLUSIONS

Thumb CMC joint arthritis is a chronic and debilitating condition that is particularly difficult to manage effectively in actively practicing surgeons. Detailed analysis of the ergonomics of the Hegar and Mathieu needle holders reveals clear differences in thumb CMC motion between the 2 instruments and provides a rational basis for why basilar joint symptoms improve with use of the Mathieu needle holder. The ergonomics of needle holders have not previously been examined in the literature. This is the first report of utilization of an alternative needle holder resulting in resolution of thumb CMC arthritis. Further study is needed to determine all factors leading to the development of occupational osteoarthritis in surgeons and measures that can be taken to prevent these conditions.

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