Diamond Stress View Radiograph for Thumb Metacarpophalangeal Hyperextension

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Abstract

Background: Successful surgical management of thumb carpometacarpal (CMC) arthritis requires treatment of coexisting metacarpophalangeal (MCP) hyperextension deformity when present. The surgeon's decision to offer thumb CMC arthritis patients the option of no additional treatment, MCP capsulodesis, or MCP arthrodesis relies on the severity of the MCP deformity measured in clinic. The authors present a novel patient-performed radiographic stress view to measure MCP hyperextension. **Methods:** Fifty-seven thumbs in 30 consecutive patients offered thumb CMC arthroplasty were enrolled. Clinic goniometer measurements, patient-performed stress view radiographs, and intraoperative manual stress views of each MCP joint were documented for study. Paired samples *t* test was used to compare the differences between the preoperative measurements and intraoperative measurements of the right and left thumb groups. **Results:** The clinic goniometer measurements were significantly different ($P = .0001$) than the MCP stress view obtained while the patient was under anesthesia. The difference in the new patient-derived x-ray stress view was not statistically significant compared with the stress view under anesthesia in the left ($P = .91$) or right ($P = .53$) groups. **Conclusions:** This new patient-performed stress view of the MCP joint allows accurate, objective measurement of hyperextension to aid in the decision making and patient education for the need of additional MCP joint surgery when addressing thumb CMC arthritis.

Keywords: CMC arthritis, carpometacarpal arthritis, MCP hyperextension, ligamentous laxity, thumb, capsulodesis, arthrodesis, hand, metacarpophalangeal hyperextension, joint

Introduction

Thumb metacarpophalangeal (MCP) hyperextension of some degree is often seen in patients with carpometacarpal (CMC) osteoarthritis. Left untreated, the Z-deformity collapse created by the pull of the extensor pollicis brevis on the MCP joint and flexor pollicis longus on the interphalangeal joint adversely affects the thumb's function.^{9,11} Surgical options to address MCP hyperextension all carry inherent risks and varying degrees of success.⁸ The lead author sought a more reliable measurement of MCP hyperextension after discovering several of his patients had markedly greater MCP hyperextension when under anesthesia than when measured by goniometer in clinic. By incorporating a reliable method of measuring MCP hyperextension into the preoperative evaluation of patients desiring thumb CMC arthroplasty, a surgeon can discuss the risks and benefits of adjunct MCP joint procedures, have necessary equipment ready, and accurately schedule operating room time (if a reliable measurement is available).

Algorithms have been proposed to simplify the decision points as to when, and how, to manage MCP hyperextension.^{1-3,11} Additional procedures such as MCP arthrodesis are recommended with greater than 40° of hyperextension, and MCP volar capsulodesis is recommended with as little as 20°. Multiple techniques are described for both capsulodesis^{6,7,14} and arthrodesis¹⁵ and incur additional counseling, operative time, and potential complications. MCP hyperextension is measured clinically with a finger goniometer (Figure 1). Measuring thumb hyperextension is more challenging than flexion as goniometers cannot reliably line up on the volar surface of the MCP joint due to the thenar muscles. Extension

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goniometers, limited to 45° of hyperextension, are difficult to use on the dorsal surface of the thumb. A patient-performed radiographic stress view of the MCP joint was devised to more easily determine the degree of hyperextension. Our hypothesis was that the new office x-ray view adequately reflects the joint hyperextension seen under anesthesia during surgery when pain is removed.

Materials and Methods

All patients enrolled in the study had symptomatic CMC joints. Sixty thumbs in 30 consecutive patients undergoing thumb CMC arthroplasty in a private practice setting were included in the study. Exclusion criteria included previous thumb surgery, leaving 57 thumbs for study. Institutional review board approval was obtained prior to enrolling patients.

Patient's thumbs were measured in clinic using a finger goniometer (Devore pocket goniometer, North Coast Medical) to the nearest degree by the senior author (Figure 1). No thumb discomfort was caused when measuring with the goniometer. The patients were then instructed to make a "diamond" between their hands by pressing the volar finger pads, not the fingertips, to stress the MCP joint (Figure 2a). This position forces the MCP joint into hyperextension if laxity exists. A 45° foam block rotates the MCP joint into a true lateral position (Figure 2b). Patients were instructed to push the hands together as "hard as you can without causing pain."

Once general anesthesia was obtained at the time of surgery, both of the patient's thumb MCP joints were individually stressed by one of the authors in the operating room. These were stressed into hyperextension and fluoroscopic images were obtained on all thumbs in a true lateral view of the MCP joint (Figure 3). The preoperative diamond stress view (Figure 4) and the intraoperative stress views were then measured using lines drawn on the dorsal cortex of the first metacarpal and proximal phalanx by two of the authors and found to be in agreement. The same surgeon measuring the MCP hyperextension in clinic also manually stressed the MCP joint in the operating room.

The goniometer, diamond stress view, and intraoperative measurements were averaged separately for both the left and right thumb MCP joint of each patient. Pearson coefficient was calculated to assess the relationship between the goniometer and diamond stress view. Paired samples *t* test was used to compare the matched differences of the goniometer view and diamond stress view to the gold standard intraoperative stress view to assess if either could be interchanged with the intraoperative stress view. *P* value < .05 was chosen as statistical significance. An outside biostatistics department performed the analysis.

Results

Fifty-seven thumbs were included in the study as 3 were eliminated due to prior surgery on the MCP joint. Averaged

Figure 1. Goniometer measurement of thumb metacarpophalangeal hyperextension.

totals of the left and right thumb from each group were calculated (Figure 5). Pearson correlation of the goniometer measurements and diamond stress view was .873 for the left thumbs and .734 for the right thumbs. This correlation supports the positive association between the new diamond stress view and established clinical method of goniometer measurement.

A paired samples *t* test was performed of the matched paired differences of the goniometer readings to the intraoperative readings as well as the diamond stress view to the intraoperative readings. Three incomplete paired measurements were excluded from this calculation. The goniometer readings were significantly different from the intraoperative stress view for both the right thumbs (*P* = .0001) and left thumbs (*P* = .0001). Therefore, the goniometer readings did not reliably measure the degree of MCP hyperextension as could be found at the time of surgery with the patient under anesthesia.

The diamond stress view was found not to be statistically significant from the intraoperative view of the right thumb (*P* = .53) and left thumb (*P* = .91) groups. The mean difference between the diamond stress view and intraoperative view for the right and left groups were 1.1 ± 8.8 SD and 0.4 ± 9.8 SD, respectively. From a statistical perspective, the diamond stress view measurements were close enough to the intraoperative stress view to be considered interchangeable.

Discussion

Progressive laxity of the CMC ligaments is thought to result in CMC dorsoradial subluxation. Metacarpophalangeal

Figure 2. Hand positioning for metacarpophalangeal (MCP) stress view. (a) Patient pushes index finger and thumb pulp against each other to form a “diamond.” (b) Elevation of the fingers with a 45° foam block rotates the thumb MCP joints into a true lateral view.

Figure 3. Same patient as Figures 2 and 4. Intraoperative stress of the thumb metacarpophalangeal (MCP) joint into hyperextension with patient under general anesthesia. (a) Left thumb MCP joint manually stressed. Note the author stabilizing the metacarpal while pulling the thumb distal phalanx (off screen). (b) Nonsurgical right thumb.

Figure 4. Same patient as Figure 2. Patient reported no pain during radiography.

hyperextension results from the CMC subluxation and imbalance of flexor-extensor forces across the joint including the extensor pollicis brevis.¹¹ Other authors have pro-

posed that the increased forces through the thumb directly cause hyperextension of the MCP joint and indirectly cause the CMC deformity.¹² The resulting Z-deformity collapse of the thumb greatly diminishes thumb function and affects the outcome of CMC arthroplasty.^{4,6}

The senior author now uses this stress view to educate his patients on the severity of the deformity, the treatment options available with their inherent risks, and potential problems if left untreated. Of the 30 patients enrolled in the study, 7 underwent arthrodesis for hyperextension greater than 40° and 4 underwent additional MCP volar capsulodesis for hyperextension greater than 20°. These adjunct procedures altered the normal postoperative protocol from early, protected motion at 2 weeks to thumb spica casting for 6 weeks.

The exact role MCP hyperextension plays in the long-term outcomes of CMC arthroplasty patients is uncertain.⁸ Poulter and Davis found no differences at 1 year between CMC arthroplasty patients with no MCP hyperextension

Figure 5. Averaged degrees of hyperextension measured by clinic goniometer measurement, “diamond” x-ray stress view, and intraoperative stress view under general anesthesia. Values are demonstrated in (a) left thumbs (n = 30) and (b) right thumbs (n = 27).

Figure 6. (a) Improperly performed thumb metacarpophalangeal (MCP) stress view with “tip to tip” contact that fails to hyperextend the MCP joint. (b) After patient education on the need for “pulp to pulp” contact, a painless stress test exhibited full thumb MCP hyperextension.

and those with untreated MCP hyperextension up to 35° .¹³ In their study, treatment of MCP hyperextension up to 30° with volar capsulodesis or temporary MCP joint pinning did not improve results. The small number of 8 untreated patients with $>35^{\circ}$ MCP hyperextension did not allow for treatment recommendations, but 1 patient with 50° hyperextension did have fusion during the study period due to pain. De Smet et al compared 36 patients with CMC arthroplasty and concomitant MCP procedures of various types with CMC arthroplasty patients and found no differences in self-assessment patient questionnaires.⁵ The authors concluded treatment of MCP hyperextension was indicated for deformities greater than 30° . Multiple authors recommend MCP arthrodesis for hyperextension greater than 40° .^{1,3,11}

Limitations of this study include potential investigator bias as the same surgeon measuring with the goniometer measured the stress views. Finger goniometer readings can have 5° of intraobserver variance and interobserver variance of 9° .¹⁰ Proving the utility of the patient-performed stress view was the premise of this study; however, these results support that clinical exam measurements underestimate MCP hyperextension that is found during surgery.

Another limitation was not separately analyzing hand dominance or operative and nonoperative thumbs. Our primary hypothesis sought to answer the validity of measuring thumb MCP hyperextension of any degree using this new radiographic view, not just symptomatic or dominant thumbs. Subdividing each group into left and right gave us 2 groups to measure the differences between the clinic measurements and the gold standard from the operating room. The fact both left and right thumb groups of the diamond stress view are not statistically significant from the intraoperative view supports our conclusion that hand dominance and CMC joint disease do not affect the diamond stress view.

Last, we learned early in the study that patient instruction and demonstration greatly aids in a properly performed stress view. Patients who place their thumbs tip to tip cannot generate a hyperextension force at the MCP joint (Figure 6).

We have modified our standard 3-view hand x-ray series for thumb CMC arthroplasty patients to include the CMC view described by Wolf et al¹⁶ and this new MCP joint stress view so as not to add additional cost to our patients. This new stress radiograph aids in educating our patients on the

need for concomitant surgery on the MCP joint, whether arthrodesis or capsulodesis, and prevents us from finding greater MCP hyperextension at the time of surgery than measured in clinic.

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Ethical Approval

This study was approved by our institutional review board.

Statement of Human and Animal Rights

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008.

Statement of Informed Consent

Informed consent was obtained from all individual participants included in the study.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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References

1. Armbruster E, Tan V. Carpometacarpal joint disease: addressing the metacarpophalangeal joint deformity. *Hand Clin.* 2008;24:295-299.
2. Berger AJ, Meals RA. Management of osteoarthritis of the thumb joints. *J Hand Surg Am.* 2015;40:843-850.
3. Blank J, Feldon P. Thumb metacarpophalangeal joint stabilization during carpometacarpal joint surgery. *Atlas Hand Clin.* 1997;2:217-225.
4. Brogan DM, Kakar S. Metacarpophalangeal joint hyperextension and the treatment of thumb basilar joint arthritis. *J Hand Surg Am.* 2012;37:837-838.
5. De Smet L, Vandenberghe L, Didden K, et al. Outcome of simultaneous surgical treatment of hyperextension of metacarpophalangeal and basal joint osteoarthritis of the thumb. *Acta Orthop Belg.* 2013;79:514-516.
6. Eaton RG, Floyd WE. Thumb metacarpophalangeal capsulodesis: an adjunct procedure to basal joint arthroplasty for collapse deformity of the first ray. *J Hand Surg Am.* 1988;13:449-453.
7. Kessler I. A simplified technique to correct hyperextension deformity of the metacarpophalangeal joint of the thumb. *J Bone Joint Surg Am.* 1979;61:903-905.
8. Klinefelter R. Metacarpophalangeal hyperextension deformity associated with trapezium-metacarpal arthritis. *J Hand Surg Am.* 2011;36:2041-2042.
9. Landsmeer JM. The coordination of finger-joint motions. *J Bone Joint Surg Am.* 1963;45:1654-1662.
10. Lewis E, Fors L, Tharion W. Interrater and intrarater reliability of finger goniometer measurements. *Am J Occup Ther.* 2010;64:555-561.
11. Lourie GM. The role and implementation of metacarpophalangeal joint fusion and capsulodesis: indications and treatment alternatives. *Hand Clin.* 2001;17(2):255-260.
12. Moulton MJ, Parentis MA, Kelly MJ, et al. Influence of metacarpophalangeal joint position on basal joint-loading in the thumb. *J Bone Joint Surg Am.* 2001;83:709-716.
13. Poulter RJ, Davis TR. Management of hyperextension of the metacarpophalangeal joint in association with trapeziometacarpal joint osteoarthritis. *J Hand Surg Am.* 2011;36:280-284.
14. Qadir R, Duncan S, Smith A, et al. Volar capsulodesis of the thumb metacarpophalangeal joint at the time of basal joint arthroplasty: a surgical technique using suture anchors. *J Hand Surg Am.* 2014;39:1999-2004.
15. Shin EK, Osterman AL. Treatment of thumb metacarpophalangeal and interphalangeal joint arthritis. *Hand Clin.* 2008;24:239-250.
16. Wolf JM, Oren TW, Ferguson B, et al. The carpometacarpal stress view radiograph in the evaluation of trapeziometacarpal joint laxity. *J Hand Surg Am.* 2009;34:1402-1406.