OPEN

PRS GLOBAL OPEN

ORIGINAL ARTICLE

Hand/Peripheral Nerve

Trapeziectomy with Interpositional Arthroplasty using Acellular Dermal Matrix: Description of Technique and Early Outcomes

April C. Cockcroft, BA*
Alexey M. Markelov, MD†

Background: Trapeziectomy with interpositional arthroplasty using Repriza acellular dermal matrix is a novel technique to treat primary and secondary carpometacarpal joint arthritis. Early studies with nonautograft interposition indicate promising post-trapeziectomy space maintenance with results similar to ligament reconstruction with tendon interposition, without the potential risks and increased operating time of harvesting a tendon autograft.

Methods: Eleven patients in a retrospective cohort were followed for a minimum of 6 weeks (mean, 12). Subjective and objective data were collected to assess pain, subjective improvement of symptoms, radiographic measurements of first metacarpal subsidence, key pinch strength, grip strength, and range of motion.

Results: Early outcomes in our cohort compare favorably to other treatment series. On average, patients received a significant pain reduction of 63%, with 36% of patients admitting to complete pain resolution. One hundred percentage of patients admitted to overall subjective improvement in symptoms. Ninety-one percentage of patients achieved postoperative opposition of the thumb and fifth digit. Comparison with preoperative x-rays showed mean thumb metacarpal subsidence of 27%. Zigzag deformity and extra-articular acellular dermal matrix migration, due to lack of patient compliance with splint, were observed complications. Only 8.3% subsidence was observed with an impressive 45% pain reduction, in a salvage patient after revision surgery for a NuGrip implant.

Conclusions: In conclusion, this is a safe and effective primary or salvage technique for Eaton grades III and IV thumb carpometacarpal arthritis with a mean subsidence within the range observed with ligament reconstruction with or without tendon interposition. Long-term study with a larger sample size is needed to investigate this technique further. *(Plast Reconstr Surg Glob Open 2018;6:e1763; doi: 10.1097/GOX.0000000000001763; Published online 14 May 2018.)*

INTRODUCTION

Arthritis of the carpometacarpal joint of the thumb is among the most common arthritic conditions of the hand. The primary form of the disease most frequently affects postmenopausal women; up to one-third of women over age 40 will have identifiable x-ray changes.[1,2] The sex differential seen in this disease may be explained by anatomic differences in the joint.[3] Although many patients remain relatively asymptomatic, a subset of patients will develop debilitating pain, thumb weakness, and instability, severely limiting hand function. Restricted mobility of the thumb and local tenderness and swelling are frequently found in conjunction with radiographic evidence of thumb carpometacarpal osteoarthritis.

Many studies have attempted to objectively assess surgical options for treatment of thumb CMC arthritis, yet each technique comes with its own complications and no 1 technique is firmly established as superior in terms

*Western U College of Osteopathic Medicine of the Pacific-Northwest, Lebanon, Ore.; and †Department of Plastic Surgery, North Bend Medical Center, Coos Bay, Ore.

Received for publication December 18, 2017; accepted March 1, 2018.

DOI: 10.1097/GOX.0000000000001763

Disclosure: *The authors have no financial interest to declare in relation to the content of this article. The Article Processing Charge was paid for by the authors. This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors. None of the authors has a financial interest in any of the products, devices, or drugs mentioned in this article.*

of the long-term patient outcomes.[4,5,6] Although trapeziectomy provides good pain relief to most patients, some authors express concern about functional problems due to shortening of the thumb or loss of pinch strength and grip strength.[7,8] Froimson first proposed to utilize tendon interposition to maintain the height of the first metacarpal in 1970.

Burton and Pellegrini[9] described the ligament reconstruction with tendon interposition (LRTI) procedure in 1986 using the flexor carpi radialis (FCR) tendon. The concept of the ligament reconstruction was to use the adjacent FCR to suspend the base of the first metacarpal distally to prevent subsidence toward the scaphoid bone after excision of the trapezium. The additional tendon interpositional arthroplasty was thought to further preserve the post-trapeziectomy space. The original article reported good pain relief and decreased proximal metacarpal migration. Long-term follow-up demonstrated reduced subsidence compared with trapeziectomy alone (11–13% compared with 50%[10]) and improved strength, function, pain, and patient satisfaction.[11,12] Since then this technique with numerous variations became the mainstay for treatment of trapeziometacarpal arthritis.[5]

Although debate still exists, in 2004, a large randomized study by Kriegs-Au et. al.[13] demonstrated that interposition in addition to ligament reconstruction adds no further benefit and when taken out of the procedure eliminates the risk for extraarticular extrusion. Although this study demonstrated that interposition may not be necessary following ligament reconstruction, it did not evaluate whether the same results could be obtained without the risks associated with autograft ligament reconstruction. Compared with LRTI, less tendon is required for ligament reconstruction alone. This significantly reduces the already low risk of morbidity due to tendinitis or flexion range of motion restrictions associated with LRTI that explains the increased risk of adverse effects compared with trapeziectomy alone.[5,14,15] Nevertheless, the risk of increased operating time, pain, scarring, soft-tissue damage and bony trauma still exist with ligament reconstruction. Therefore, surgeons recognize that although ligament reconstruction with or without tendon interposition may be the mainstay of treatment, it is far from a perfect technique and continue to research alternative treatments.[6]

To reduce donor-site morbidity and operative time, alternatives to autograft harvest have since been developed with varying success to compete with LRTI to preserve the post-trapeziectomy space. Such techniques use nonautograft substances to mimic the suspension concept of ligament reconstruction and/or the interpositional arthroplasty of LRTI's autograft tendon interposition. Many nonautograft substances have been used with varying results including cadaveric acellular dermal matrix, sutures, cadaveric allograft fascia lata, costochondral allograft, silicone, polypropylene and Gore-Tex.[16,17,18,19,20,21] Our study is unique in that it uses Repriza (Promethean Life Sciences Inc., Pittsburgh, Pa.), a radiated cadaveric acellular dermal matrix product.

Long-term results of nonautograft suture suspension arthroplasty (mean subsidence of 30%) are competitive with the suspension achieved with autograft ligament reconstruction.[20,21] Early studies show that primary treatment with interpositional arthroplasty with acellular dermal matrix (ADM) after trapeziectomy with or without additional suspension can be as effective at maintaining the post-trapeziectomy space as LRTI.[22,23] In the study by Kokkalis et al.[22] using ADM and suspension, patients achieved a significant pain reduction, increased grip, and pinch strength, a less than 32% reduction in arthroplasty space, and no adverse reactions. However, in the study by Yao et al.[23] with ADM interposition alone achieved a mean subsidence of 11%, which is equal to the lowest observed with LRTI.[11,12] Like these previous ADM interpositional arthroplasty studies, our study also focuses on primary treatment of first CMC joint arthritis.[22,23] Additionally, our study uniquely evaluates a salvage case.

HYPOTHESIS

We hypothesize trapeziectomy with interpositional arthroplasty using an acellular dermal allograft is a safe and effective primary and salvage technique for Eaton grades III and IV thumb carpometacarpal arthritis. In compliant patients, we predict early outcomes of at least a 50% pain reduction on average, opposition of thumb to fifth digit as indication of functional range of motion, subjective improvement in symptoms, and thumb metacarpal subsidence within the range of that observed with ligament reconstruction with or without tendon interposition. Furthermore, by design, our procedure should avoid the morbidity and operative time associated with harvesting an autograft tendon and the increased risk of bone trauma that is possible with ligament reconstruction procedures.

METHODS

Study design was that of a retrospective cohort with all procedures performed by a single surgeon from December 2016 to September 2017 for symptomatic osteoarthritis. The treatment cohort consisted of 8 females (72.7%) and 3 males (27.3%) with an overall mean age of 69.4 years. One female received the treatment as a salvage procedure. All other participants received surgery as their primary treatment option for basal thumb arthritis. Fifty-five percent of our cohort had an Eaton radiographic score of 3 with 45% in stage 4. The Eaton classification (Table 1) is 1 of the most commonly used in clinical practice.[24] It relies on radiographic changes only and does not consider patient's subjective complaints and physical examination findings. Each patient was followed until they were discharged from hand-therapy upon meeting their established pain reduction and thumb function goals. Overall average follow-up was 12 weeks. The 3 patients who did not attend hand therapy were still followed by the physician for a minimum of 6 weeks.

Subjective and objective data were collected to assess pain, functional improvement, key pinch strength, grip strength, range of motion, and radiographic measurements (Fig. 1). Due to the retrospective nature of this study, no preoperative measurements of the ipsilateral or contralateral hand for statistical comparison were avail-

Table 1. Eaton-Littler Classification System for Basal Joint Arthritis of the Thumb

Staging	Characteristics
Stage I	Normal articular cartilage with possible joint widening due to effusion and laxity of the beak ligament
Stage II	Narrowing of the joint space, with debris and osteophytes smaller than 2 mm in size, and more than one-third subluxation of the metacarpal
Stage III	Severe joint narrowing, with osteophytes and debris greater than 2 mm in size
Stage IV	Pantrapezial arthritis with involvement of scaphotrapezial joint

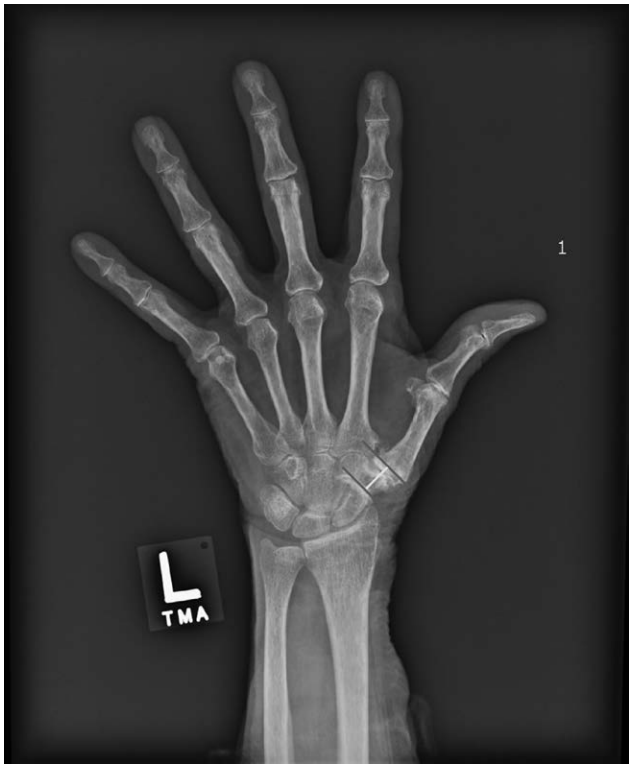

Fig. 1. Measurement method of trapezial height. Measure the trapezial height from scaphoid distal pole to first metacarpal base in posteroanterior view perpendicular manner to scaphoid distal pole.

able for strength or range of motion. Trapezial height was measured from scaphoid distal pole to first metacarpal base in posteroanterior view in a perpendicular manner to scaphoid distal pole. To calculate radiographic subsidence, the difference between the preoperative trapezium height and postoperative post-trapeziectomy space was divided by the preoperative trapezium height. An informed consent was obtained from all participants in the study. Microsoft Excel's data analysis program was used for statistical analysis. Due to small sample size, a 2-sample *t* test assuming equal variance was used to determine statistical significance between the pre- and postoperative variables. *P* values were 2-tailed, and values equal to or less than 0.05 were defined as statistically significant.

Surgical Procedure

First sterilize skin and drape in standard surgical fashion. Exsanguinate upper extremity with Esmarch bandage, then inflate tourniquet to 250 mm Hg. Incise the skin overlying the right thumb CMC joint. Identify and retract radial sensory nerve branch to protect it from injury

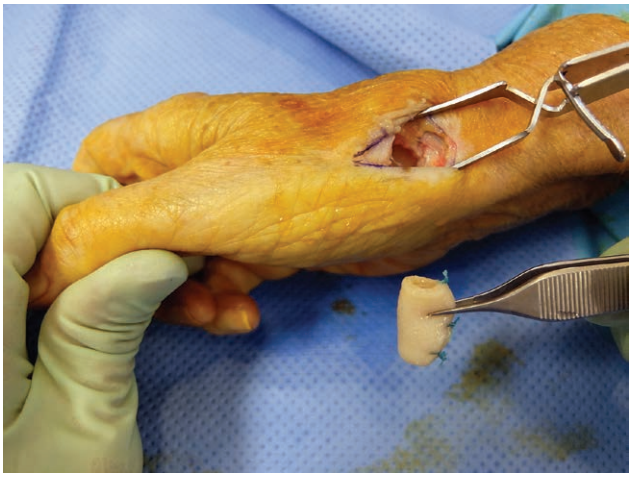

Fig. 2. Roll then Suture ADM (Repriza).

while dissecting through the subcutaneous tissues. Continue dissection to the first dorsal extensor compartment and identify and retract extensor pollicis brevis tendons to protect from injury. Open CMC joint capsule and create joint capsule flaps. Identify the trapezial bone.

Place freer elevator in the CMC joint and confirm with fluoroscopy, before proceeding with exposure of the trapezium. Protect radial artery from injury then circumferentially dissect the trapezial bone. Divide the trapezial bone into pieces using an oscillating blade and use rongeur forceps to remove the pieces of the trapezium. Confirm that the entire trapezium has been removed using fluoroscopy then visually confirm that the distal pole of the scaphoid is intact and does not seem to be involved in the arthritic process. Change gloves and irrigate the wound with triple antibiotic solution. To prevent subsidence of the thumb, proceed with interpositional arthroplasty using ADM without ligament reconstruction.

Roll a 2×3 cm piece of Repriza ADM on itself then suture with 3-0 Ethibond (Ethicon US, LLC, Somerville, N.J.) to maintain this shape (Fig. 2). Place Repriza ADM into the post-trapeziectomy space using no touch technique (Fig. 3). Avoid catching tendon or tendon sheath, while closing the joint capsule with 4-0 PDS (Ethicon US, LLC) figure of 8 sutures. The skin is closed using 4-0 PDS deep dermal and running subcuticular sutures. Apply Dermabond and sterile dressing. Finally, place patient in a thumb Spica splint.

Postoperative Patient Instructions

Follow-up in clinic at 2 weeks for postoperative x-rays and to be fitted for a removable custom-made thumb Spica

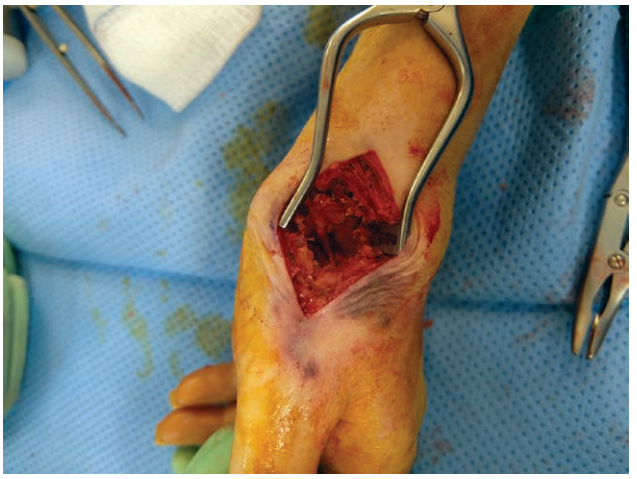

Fig. 3. Post-trapeziectomy joint space.

splint; wear for a minimum of 2 weeks (Fig. 4, 5). Patient is referred to hand therapy and instructed to continue with therapy until goals are met.

RESULTS

Patients achieved a significant reduction in pain scores ($t(20) = 2.09$, $P < 0.05$) on a 10-point scale from mean preoperative score 7.7 (SD = 1.74) to mean postoperative score 1.4 (SD = 1.15), with a 63% pain reduction on average (SD = 16.2%, n = 11). Furthermore, 36% of patients were reported to be pain free at the latest follow-up.

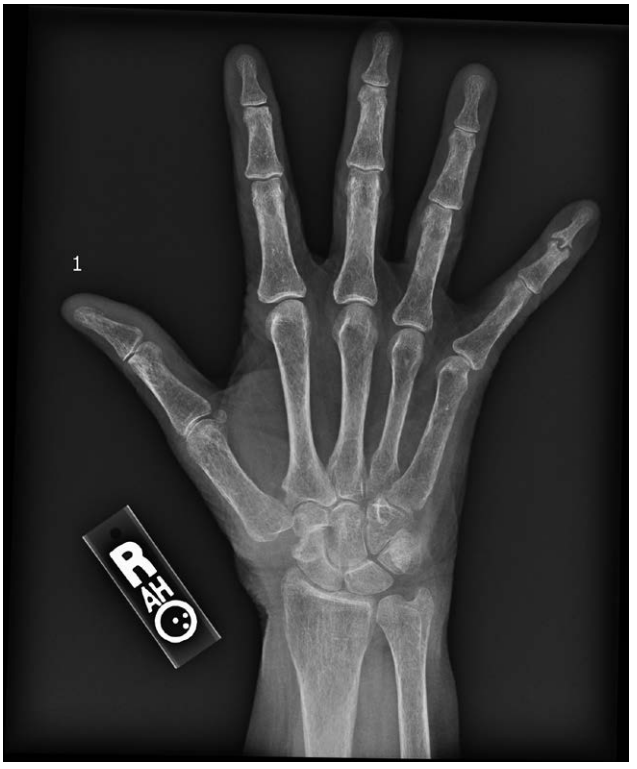

Fig. 4. Postoperative x-ray of a 75-year-old female with 19.6% subsidence.

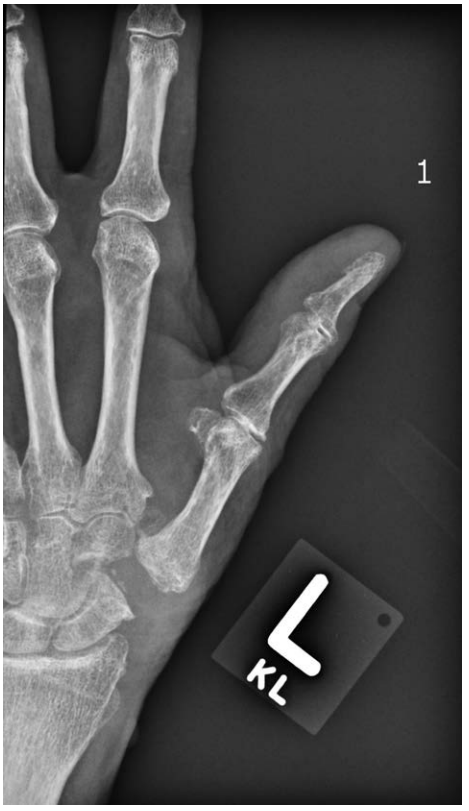

Fig. 5. Postoperative x-ray of an 81-year-old female with 2.9% subsidence.

Ninety-one percentage of patients achieved postoperative opposition of the thumb and fifth digit, indicating functional range of motion. One hundred percentage of patients admitted to overall subjective improvement in symptoms, including pain and function. Finally, mean cohort subsidence was 27% ($t(20) = 2.09$, $P < 0.05$, SD = 25%, n = 11).

No association was calculated between patient pain reduction and calculated subsidence. Although 1 patient experienced zigzag deformity and another required a revision surgery after extraarticular ADM migration, no patients suffered from bony trauma, infections, or foreign body reactions. Average postoperative grip strength was 28.4 lbs (SD = 13.6 lbs), and key pinch strength was 5.7 lbs (SD = 2.3 lbs; n = 7). Mean postoperative measurements showed radial and palmar abduction of 49.4° (SD = 4°) and 45° (SD = 7°; n = 7). Twenty-seven percentage of patients did not have postoperative strength or range of motion measurements due to loss of follow-up.

DISCUSSION

Considering the favorable outcomes in patient pain reduction (mean, 67%), opposition (91% of cohort), and subjective improvement in patient symptoms (100%) trapeziectomy with interpositional arthroplasty using ADM appears to be an effective procedure, comparable with LRTI, the mainstay of treatment for this condition.

Our mean subsidence was 27%. Although this is greater than the lowest mean subsidence recorded with LRTI

or ADM interposition (11%),[11,12,23] it is less than that in the study by Kriegs-au et al.[13], which argued that interposition in addition to ligament reconstruction adds no benefit (LRTI = 37% and ligament reconstruction only = 42%). Therefore, although our study is not without limitations, our mean subsidence is within the range of that achieved with ligament reconstruction with or without interpositional arthroplasty. Furthermore, it is comparable with other nonautograft subsidence results, such as suture suspension (30%)[20,21] and ADM interposition with additional suspension (32%).[22]

We believe that these outcomes justify the expense of ADM. We use a 2×3 cm piece of Repriza acellular dermal matrix (Promethean LifeSciences, Inc., Pittsburgh, Pa.) with the cost of $100. The use of ADM allows us to reduce operative time required for tendon harvest, which makes it even more cost effective for patients than ligament reconstruction with or without tendon interposition. Furthermore, we prefer this matrix because it does not require refrigeration and has a 4-year shelf life at ambient temperature.

The volume of ADM that we use is much larger than the average volume of FCR tendon or pollicis longus tendon harvested. This allows us to avoid thumb shortening and reduced pinch strength due to subsidence of the first metacarpal. It also prevents impaction of the first metacarpal on the scaphoid bone. Subjectively, our patients who had LRTI performed in their opposite hand reported markedly better key pinch strength with the use of our technique.

In our study, the 4 patients with the highest subsidence, between 44% and 80%, did not attend postoperative hand therapy due to noncompliance and/or experienced complications, where 1 of the 2 complications can be explained by patient noncompliance with postoperative instructions. This infers the importance of stressing patient compliance with postoperative instructions.

The patient who required revision surgery for ADM migration did not comply with postoperative orders to immobilize her thumb and immediately and repetitively used her hand without a splint. This joint movement, following capsulotomy, led to ADM migration outside of the joint space, causing a deformity visible at 2-weeks postoperatively that required removal of all ADM in revision surgery. In comparison with preoperative images, without ADM to maintain the posttrapeziectomy space, the patient essentially had trapeziectomy alone, which may explain their above average subsidence of 47%.

Our technique proved to also be an effective salvage option in our 1 female patient who required revision surgery after placement of pyrocarbon CMC joint implant (NuGrip). Our procedure marked the patient's fourth surgery to treat intractable basal thumb pain and regression of function. The 2 prior revision surgeries included removal of symptomatic heterotopic osteophytes and implant replacement. The latter led to fracture of the trapezium in which the implant was placed. This is consistent with the 1 study that evaluated short-term outcomes of CMC arthroplasty with the NuGrip implant, which concluded that revision surgery for instability and retained osteophytes are the main pitfalls.[25] Post-trapeziectomy, the ADM interpositional arthroplasty maintained the position of the first metacarpal nearly and the implant itself, with only 8.3% subsidence. Despite a tortuous preoperative path, this patient achieved pain reduction, radial abduction, and palmar abduction scores less than the mean by only 1–2 SDs. For example, the patient's previously intractable 10/10 pain reduced by 45% with our procedure.

Of course, with such a small sample size and short follow-up period, our study requires reevaluation with longer follow-up of a larger cohort.

CONCLUSIONS

This study is unique in that it shows a case of post-trapeziectomy interpositional arthroplasty with cost-effective radiated ADM used successfully as a salvage technique. Furthermore, this study adds to the pool of other small studies demonstrating that this is an effective treatment, comparable with ligament reconstruction with or without tendon interposition, for primary basilar thumb arthritis. We confirmed our hypothesis that patients would achieve at least a 50% pain reduction on average, opposition of the thumb to fifth digit as indication of functional range of motion, subjective improvement in symptoms, and thumb metacarpal subsidence within the range of that observed with ligament reconstruction with or without tendon interposition. Furthermore, by design, our procedure avoids the morbidity and operative time associated with harvesting an autograft tendon and the increased risk of bone trauma that is possible with ligament reconstruction procedures. Although our study is not without sample size and length of follow-up limitations, it does contribute additional information on this technique to the literature.

STATEMENT OF INFORMED CONSENT

Informed consent was obtained from all individual participants included in the study. Additional informed consent was obtained from all individual participants whose x-rays or intraoperative images are included in this article.

STATEMENT OF HUMAN AND ANIMAL RIGHTS

Written consent was obtained from the local Ethics Committee of North Bend Medical Center (Coos Bay, Ore.). 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 (5). Informed consent was obtained from all patients for being included in the study.

April C. Cockcroft, BA
Western University College of Osteopathic Medicine
of the Pacific-Northwest
200 Mullins Dr.
Lebanon, OR 97355
E-mail: acockcroft@westernu.edu

REFERENCES

1. Armstrong AL, Hunter JB, Davis TR. The prevalence of degenerative arthritis of the base of the thumb in post-menopausal women. *J Hand Surg Br.* 1994;19:340–341.
2. Haara MM, Heliövaara M, Kröger H, et al. Osteoarthritis in the carpometacarpal joint of the thumb. Prevalence and associations with disability and mortality. *J Bone Joint Surg Am.* 2004;86-A:1452–1457.
3. Marzke MW, Marzke RF. Evolution of the human hand: approaches to acquiring, analysing and interpreting the anatomical evidence. *J Anat.* 2000;197:121–140.
4. Wolf JM, Delaronde S. Current trends in nonoperative and operative treatment of trapeziometacarpal osteoarthritis: a survey of US hand surgeons. *J Hand Surg Am.* 2012;37:77–82.
5. Wajon A, Vinycomb T, Carr E, et al. Surgery for thumb (trapeziometacarpal joint) osteoarthritis. *Cochrane Database Syst Rev.* 2015;2:CD004631.
6. Vermeulen GM, Slijper H, Feitz R, et al. Surgical management of primary thumb carpometacarpal osteoarthritis: a systematic review. *J Hand Surg Am.* 2011;36:157–169.
7. Gervis WH, Wells T. A review of excision of the trapezium for osteoarthritis of the trapezio-metacarpal joint after twenty-five years. *J Bone Joint Surg Br.* 1973;55:56–57.
8. Yang SS, Weiland AJ. First metacarpal subsidence during pinch after ligament reconstruction and tendon interposition basal joint arthroplasty of the thumb. *J Hand Surg Am.* 1998;23:879–883.
9. Burton RI, Pellegrini VD Jr. Surgical management of basal joint arthritis of the thumb. Part II. Ligament reconstruction with tendon interposition arthroplasty. *J Hand Surg Am.* 1986;11:324–332.
10. Froimson AI. Tendon arthroplasty of the trapeziometacarpal joint. *Clin Orthop Relat Res.* 1970;70:191–199.
11. Tomaino MM, Burton RI, Pelligrini VD. Arthroplasty of the thumb basal joint: long-term follow-up of ligament reconstruction with tendon interposition. *Orthop Trans.* 1993;17:579.
12. Tomaino MM, Pellegrini VD Jr, Burton RI. Arthroplasty of the basal joint of the thumb. Long-term follow-up after ligament reconstruction with tendon interposition. *J Bone Joint Surg Am.* 1995;77:346–355.
13. Kriegs-Au G, Petje G, Fojtl E, et al. Ligament reconstruction with or without tendon interposition to treat primary thumb carpometacarpal osteoarthritis. A prospective randomized study. *J Bone Joint Surg Am.* 2004;86-A:209–218.
14. Lins RE, Gelberman RH, McKeown L, et al. Basal joint arthritis: trapeziectomy with ligament reconstruction and tendon interposition arthroplasty. *J Hand Surg Am.* 1996;21:202–209.
15. Naidu SH, Poole J, Horne A. Entire flexor carpi radialis tendon harvest for thumb carpometacarpal arthroplasty alters wrist kinetics. *J Hand Surg Am.* 2006;31:1171–1175.
16. Muermans S, Coenen L. Interpositional arthroplasty with Gore-Tex, Marlex or tendon for osteoarthritis of the trapeziometacarpal joint. A retrospective comparative study. *J Hand Surg Br.* 1998;23:64–68.
17. Taghinia AH, Al-Sheikh AA, Upton J. Suture anchor suspension and fascia lata interposition arthroplasty for basal joint arthritis of the thumb. *Plast Reconstr Surg.* 2008;122:497–504.
18. Swanson AB. Disabling arthritis at the base of the thumb: treatment by resection of the trapezium and flexible (silicone) implant arthroplasty. *J Bone Joint Surg Am.* 1972;54:456–471.
20. DelSignore JL, Accardi KZ. Suture suspension arthroplasty technique for basal joint arthritis reconstruction. *Tech Hand Up Extrem Surg.* 2009;13:166–172.
21. DelSignore J, Zambito-Accardi K, Ballatori S. Suture suspension arthroplasty for thumb carpometacarpal arthritis reconstruction: long-term outcome. *J Hand Surg.* 2015;40:e29–e30. doi:10.1016/j.jhsa.2015.06.053.
22. Kokkalis ZT, Zanaros G, Weiser RW, et al. Trapezium resection with suspension and interposition arthroplasty using acellular dermal allograft for thumb carpometacarpal arthritis. *J Hand Surg Am.* 2009;34:1029–1036.
23. Yao CA, Ellis CV, Cohen MJ, et al. Preserving the posttrapeziectomy space with a human acellular dermal matrix spacer: a pilot case series of patients with thumb carpometacarpal joint arthritis. *Plast Reconstr Surg Glob Open.* 2013;1:e65.
24. Eaton RG, Lane LB, Littler JW, et al. Ligament reconstruction for the painful thumb carpometacarpal joint: a long-term assessment. *J Hand Surg Am.* 1984;9:692–699.
25. Van De Kimmenade R, Bullens P, Raven E. Short term results of the ascension NuGrip CMC implant for thumb carpometacarpal osteoarthritis. *Internet Journal of Orthopedic Surgery.* 2014;22:p1.