First Carpometacarpal Joint Denervation: A Systematic Review

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Purpose The first carpometacarpal (CMC) joint is a frequent location of osteoarthritis in the hand. The denervation of the first CMC joint has gained traction as a viable treatment for CMC arthritis. This study reviewed literature on CMC denervation for first CMC arthritis.

Methods A systematic review of papers and abstracts was conducted. The preferred reporting items for systematic reviews and meta-analyses guidelines were followed. Articles including the results of CMC denervation were included. We compiled data on patient demographics, preoperative testing, intraoperative technique, and postoperative outcomes. Anatomic literature was also reviewed to assess agreement on the innervation of the first CMC joint.

Results Six anatomic studies and 9 clinical studies were included in this systematic review. Pinch strength, grip strength, and Kapandji scores increased on average in patients. Pain relief was noted on average in patients in 5 studies that reported pain outcomes. In studies that reported postoperative complications, the most frequent complications were radial paresthesias, hypoesthesia dorsal and/or distal to the surgical site, and wound infection.

Conclusions The innervation of the CMC joint is controversial. This is reflected in clinical practice, wherein varied surgical approaches are used. Carpometacarpal denervation shows promise as an option to treat patients with CMC arthritis without joint instability, but its results vary. Additional clinical studies with longer-term follow-up and control groups are necessary to better determine its longevity and efficacy. *(J Hand Surg Am. 2022;47(8):793.e1-e8. Copyright © 2022 by the American Society for Surgery of the Hand. All rights reserved.)*

Type of study/level of evidence Therapeutic V.

Key words Arthritis, basilar joint arthritis, denervation, first carpometacarpal arthritis, nerve.

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THE FIRST CARPOMETACARPAL (CMC) joint is a frequent location of osteoarthritis (OA) in the hand.[1] Carpometacarpal arthritis has a predilection for older women, and this progressive disease can be debilitating and can worsen patients' quality of life.[1,2] Although debated, the cause of this condition is generally thought to be mechanical wear of the joint, which eventually causes pain.[3]

A tiered approach is often used to treat first CMC OA.[3] Noninvasive treatments, including lifestyle modification, physical or occupational therapy, and nonsteroidal anti-inflammatory drugs, are tried first. If these nonsurgical measures fail, joint injections can also be used. Corticosteroids, hyaluronic acid, and autologous fat grafts have been used as means of decreasing joint inflammation and providing temporary symptomatic relief.[4–6] If patients continue to have unabated pain, surgical treatment is considered.

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The first surgical treatments of CMC OA involved the use of trapeziectomy.[7] Trapeziectomy is an effective treatment for CMC OA, although occasional reports of subjective weakness have prompted a host of procedural modifications, including hematoma distraction arthroplasty, CMC arthroplasty using implants, CMC joint arthrodesis, ligament reconstruction, tendon interposition, or a combination of 2 procedures (ligament reconstruction and tendon interposition [LRTI]).[8] Of these procedures, LRTI is more frequently used in the United States according to a recent survey of a Medicare database.[9] A Cochrane review comparing LRTI with simple trapeziectomy found no improvements in clinical outcomes, including objective strength measures, although it did note a higher complication rate among patients who underwent LRTI.[10] More recently, suture button suspension or tight rope arthroplasties have emerged as viable options for treating CMC arthritis, although the use of these devices adds direct costs over the use of simple trapeziectomy, and there is potential for complications such as second metacarpal fracture.[11,12]

Nearly all surgical procedures resolve the symptoms associated with CMC arthritis in most patients with relatively good efficacy, at least in the short term. However, all the numerous variations of trapeziectomy carry some risk of scaphometacarpal abutment and inherently alter joint kinematics.[13] Furthermore, each of these procedures has inherent risk of morbidity and requires a period of postoperative recovery.[10]

The denervation of the first CMC joint has gained traction as a viable treatment for first CMC arthritis. The promise of the procedure lies in its potential to relieve patient symptoms while potentially reducing the surgical morbidity and postoperative recovery times associated with more invasive procedures. In this study, we systematically reviewed anatomic and clinical literature on CMC denervation for CMC OA. We hypothesized that joint denervation is an effective way of treating the pain associated with first CMC arthritis.

MATERIALS AND METHODS

A systematic review of papers and abstracts was conducted according to the preferred reporting items for systematic reviews and meta-analyses guidelines (Figs. 1, 2). The anatomic literature was reviewed to assess agreement on the innervation of the first CMC joint. To identify anatomic literature for inclusion, the following search terms were used: [thumb joint OR carpometacarpal joint OR CMC joint] AND [innervation] and carpometacarpal joint denervation anatomy. The following search terms were used to gather clinical studies: [carpometacarpal OR CMC OR thumb joint OR CMC joint OR carpometacarpal joint] AND [denervation]. Two blinded reviewers (K.Re. and K.Ro.) independently reviewed the studies. Disagreements were resolved via a discussion. Articles including the results of first CMC denervation were included. Non-English language articles were excluded. We compiled data on patient demographics, preoperative testing, intraoperative technique, and postoperative outcomes.

RESULTS

Six anatomic studies were included after the application of the inclusion and exclusion criteria (Fig. 1).[14–19] The nerves reported to innervate the first CMC joint in cadavers were the radial nerve (6 of 6 studies), median palmar cutaneous branch (4 of 6 studies), median thenar motor branch (4 of 6 studies), lateral antebrachial cutaneous nerve (LABCN) (4 of 6 studies), and deep motor branch of the ulnar nerve (1 of 6 studies) (Fig. 2).[14–19] A more detailed representation of the anatomic study results can be found in Table 1.

One hundred sixty-nine patients from 9 clinical studies were included in this systematic review (Fig. 3).[19–27] Eight of the studies were retrospective case series. One was a randomized controlled trial comparing denervation with LRTI. There was an overlap in study patients between 2 studies by the same author; the study with the greater proportion of patients followed up in person, as opposed to those followed up via phone, was selected to represent these patients in this systematic review.[25,26] The mean patient age was 60.1 years, and 79.7% of the patients were women (Table 2). In studies reporting employment status, 60.7% of the patients were employed. Specific patient occupations were reported in 2 of the 9 studies.

In all cases, denervation was performed as the first surgical intervention for first CMC arthritis. In studies on first CMC arthritis, the procedure was indicated for adult patients without evidence of joint instability. One study excluded patients with Eaton and Littler stage I and IV OA.[24]

Preoperative nerve blocks to identify sensory innervation of the CMC joint were performed in 3 of the 9 studies (Table 3).[19,21,24] In 1 study, the preoperative nerve block was performed by an

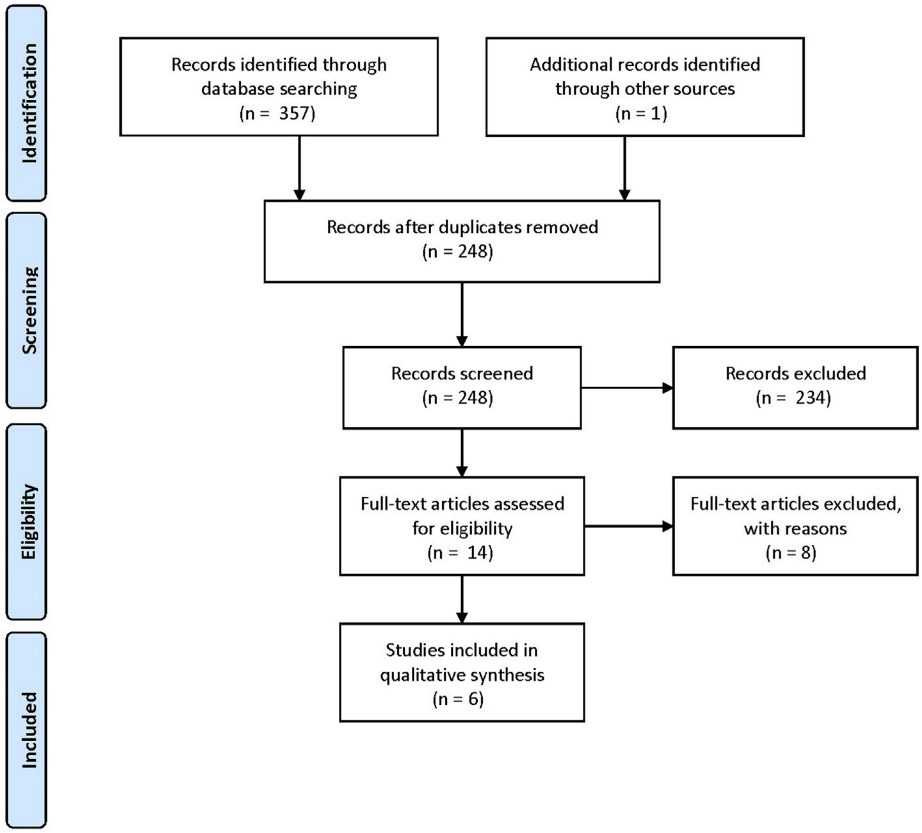

FIGURE 1: Flowchart of anatomic study selection according to PRISMA guidelines. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

occupational therapist, whereas in the other 2, the operating surgeon performed the nerve block.[19,21,24] The most frequently cited reason for avoiding this diagnostic step by other study authors was the diffusion of anesthetic agent into nearby nerves, reducing the specificity of this test.

Seven different operative approaches to expose CMC joint innervation were described by the 9 studies (Table 3). Eight of the 9 studies attempted to denervate the radial nerve's contribution to the joint, 7 specified attempting to denervate the LABCN's and palmar cutaneous branch of the median nerve's contributions to the joint, and 5 aimed to denervate the thenar branch of the median nerve's contribution to the joint.[19−16,24−27] One study that only specified denervating the radial nerve's contribution to the joint also ablated the entire CMC capsule.[21] Another study denervated the posterior interosseous nerve in addition to the radial nerve, LABCN, and median nerve branches.[27] Dellon[23] did not specify denervating the radial nerve's contribution to the joint in their technique, which involved volar denervation and osteophyte resection for volar-limited OA. Two studies described injecting nerves with lidocaine directly prior to ablating them to avoid pain centralization.[19,23]

The outcomes assessed by the authors included strength, pain, the Michigan Health Questionnaire, and return-to-work times. Aggregate denervation outcomes were not calculated because of heterogeneity in outcome reporting; the summarized individual study results for outcomes and complications can be found in Tables 4 and 5, respectively. The follow-up times ranged from 6 months to 12 years. Of 7 studies that reported mean follow-up times, 4 had mean final follow-up times less than or equal to 2 years after denervation.

Objective measures, including pinch strength, grip strength, and Kapandji score, improved on average in patients who underwent denervation (Table 4). Pain relief was reported on average in patients after denervation in all 5 studies that reported pain outcomes.

A potential cause for revision suggested by 1 study group was inappropriately indicated denervation in patients.[21] One example of an inappropriate indication for surgery given by the authors was preoperative joint instability that denervation would not address. There were also intraoperative causes of

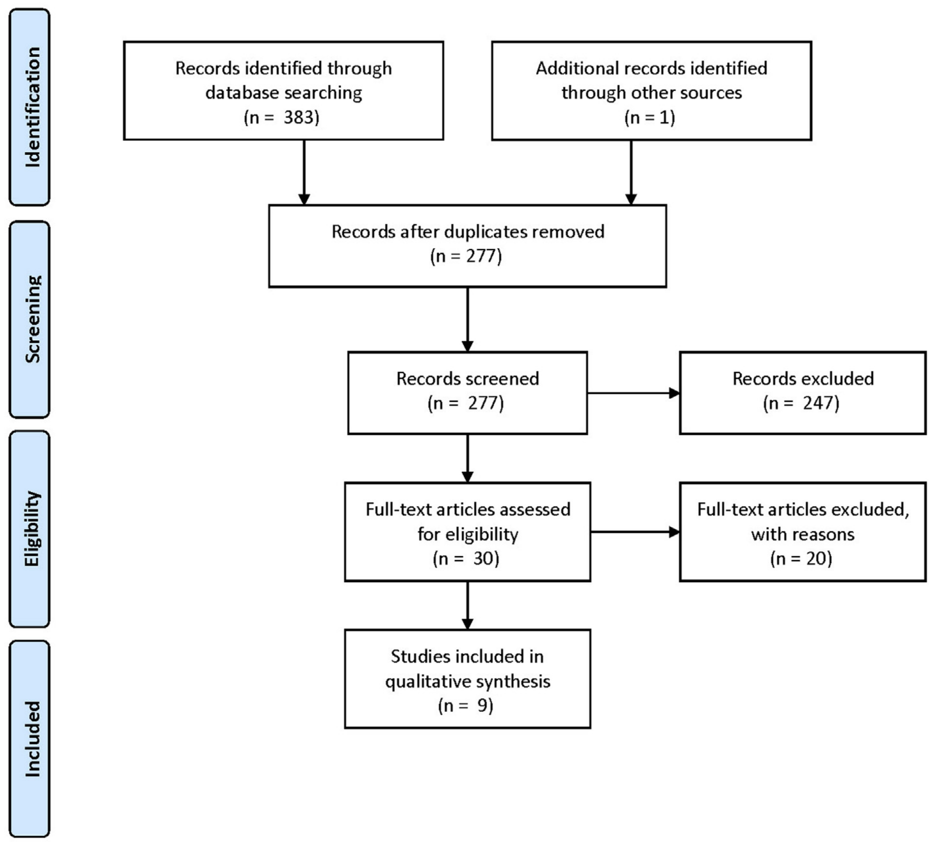

FIGURE 2: Flowchart of clinical study selection according to PRISMA guidelines. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

TABLE 1. Anatomic Innervation of the CMC Joint

Author	Cadavers	ThBMN	PCBMN	RN	LABCN	UN
Fukumoto et al[14]	20			X (95%)	X (100%)	
Wilhelm[15]		X	X	X	X	
Loréa[16]	10	X	X	X	X	
Miki et al[17]	19	X (47%)	0	X (58%)		X (47%)
Poupon et al[18]	15	X (>45%)	X (>45%)	X (100%)		
Tuffaha et al[19]	10		X (70%)	X (40%)	X (100%)	

LABCN, lateral antebrachail cutaneous nerve; PCBMN, palmar cutaneous branch median nerve; RN, radial nerve; ThBMN, thenar branch median nerve; UN, ulnar nerve.

X indicates that the nerve or nerve branch was found to innervate to the first CMC joint by the anatomical study listed.

reoperation mentioned by other study groups, including missed CMC joint innervation and neuroma formation.[19,23] In the 169 patients who underwent denervation, the frequent complications included radial nerve paresthesias (20 patients), patchy hypoesthesia dorsal and/or distal to the surgical incision (9 patients), and postoperative wound infection (3 patients) (Table 5). The revision rates ranged from 0% to 25.7% in the studies included. One study reported an 8.3% revision rate for LRTI at a mean follow-up of 15 months.[19] The only prospective cohort study comparing a denervation cohort with a trapeziectomy cohort reported a revision rate of 25.7% (9 of 35 patients) in the denervation group relative to 0% (0 of 10 patients) in the trapeziectomy group at 60-month follow-up.[21] Seven of the 9 studies reported no revision surgeries at a mean follow-up range of 8−125.6 months after the initial denervation. In 3 studies that provided longer-term outcomes (>4 years of mean follow-up), at least

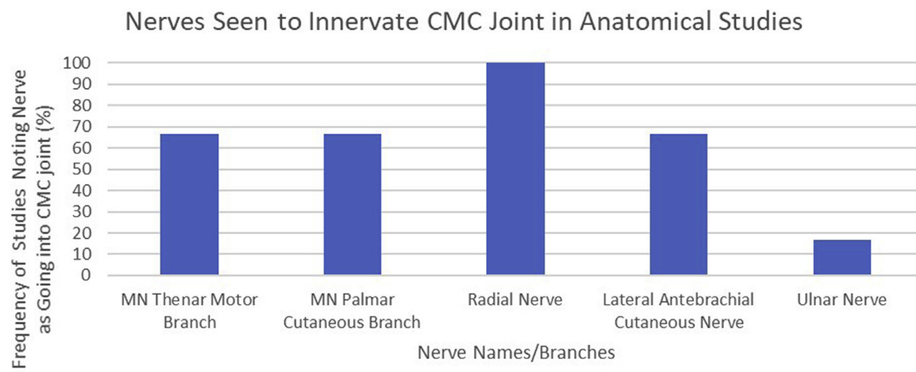

FIGURE 3: This figure shows the frequency with which anatomic studies have noted nerves to innervate the CMC joint in at least 1 of their study cadavers. Number of patients in the study (n = 30); 24 patients had follow-up data.

TABLE 2. A Summary of First CMC Denervation Study Demographics*

First Author	Year	Patients	Hands	Mean Age (y)	Sex (% F)†	LOE
Tuffaha et al[19]	2019	12	12	59 (46−74)	75	IV
Giannikas et al[20]	2009	15	15	53	100	IV
Salibi et al[21]	2019	35	35	58 (41−72)	82.9	II
Arenas-Prat[22]	2012	16	18			IV
Loréa[16]	2003	14	14	60 (30−77)		IV
Dellon[23]	2016	3	5	64.3 (54−83)	50	IV
Donato et al[24]	2018	8	11	63.4 (7.4) (55−77)‡	62.5	IV
Ehrl et al[25]	2016	42	42	62.7 (9.9)	80.1	IV
Giesen et al[27]	2017	24§	24	62 (39−86)	73.3	IV

LOE, level of evidence.
*37 patients were followed up via in-person examinations, and 23 were followed up via phone.
†"% F" indicates percentage of women.
‡The mean age was reported as mean (SD) (range).
§n = 30 patients, 31 patients' hands were operated upon. 24 patients had follow-up data.

70% of the patients did not undergo a reoperation.[21,23,25]

DISCUSSION

The studies included in this review generally reported improvement in pain, strength, and thumb opposition after denervation. There was considerable variability in surgical techniques and outcome reporting among the studies, making it difficult to generalize individual study results. The lack of a control group in 8 of the 9 studies also made it challenging to contextualize the outcomes.

There is uncertainty regarding the innervation of the CMC joint in the literature. Miki et al[17] represents the sole study that identified the innervation of the CMC joint by the deep motor branch of the ulnar nerve. To our knowledge, no first CMC joint anatomic studies have reproduced the findings of ulnar nerve innervation, and the denervation of the deep motor branches of the ulnar nerve has not been implemented into clinical practice. Most studies agree on the potential for joint innervation by the following nerves: radial nerve, thenar motor branch of median nerve, palmar cutaneous branch of median nerve, and LABCN. However, even the radial nerve, which is widely accepted to innervate the CMC joint, did not supply an identifiable branch to the CMC joint in 60% of cadavers in 1 recent study.[19] Anatomic studies make it clear that there is considerable variability in the innervation of the CMC joint, which might have important clinical and surgical implications.

Identifying a superior surgical approach is challenging because of varying patient anatomy and clinical symptoms as well as differing postoperative expectations and requirements. The variability in

TABLE 3. Perioperative Patient Characteristics and Denervation Techniques

First Author	Block	Operative Technique	Nerve Branches Targeted: RN	PCBMN	ThBMN	LABCN	PIN
Tuffaha et al[19]	X	Wagner approach	X	X		X	
Giannikas et al[20]		Incision from the FCR to the second extensor compartment	X	X	X	X	
Salibi et al[21]	X	Dorsoradial incision + capsule ablation	X				
Arenas-Prat[22]		Dorsoradial incision + Wagner approach	X	X	X	X	
Loréa[16]		One palmar incision + 1 dorsal incision	X	X	X	X	
Dellon[23]		2-cm incision at the base of the first metacarpal					
Donato et al[24]	X	Transverse palmar incision from the FCR to the first extensor compartment, dorsal incision at the first interosseous space apex	X	X	X	X	X
Ehrl et al[25]		Radial S-shaped thumb incision + synovectomy and osteophytes excision	X	X		X	
Giesen et al[27]		Loréa technique + dorsal wrist incision into the fourth extensor compartment to resect 1 cm posterior to the interosseous nerve	X	X	X	X	X

FCR, flexor carpi radialis; LABCN, lateral antebrachail cutaneous nerve; PCBMN, palmar cutaneous branch median nerve; PIN, posterior interosseous nerve; RN, radial nerve; ThBMN, thenar branch median nerve.

X indicates that a preoperative nerve block was utilized or a given nerve branch was targeted by the nerve block.

TABLE 4. Outcomes of Denervation*

First Author	Key Pinch	Grip Strength	Kapandji Score	Pain
Tuffaha et al[19]	87.5%*	76%*		91.7%*
Giannikas et al[20]	Doubled*	Doubled*	100%†	−65% on average
Salibi et al[21]			+1.92	
Dellon[23]				100%†
Donato et al[24]		Pre 38.4 ft/lb Post 50.2 ft/lb		Pre 7.8 Post 2.4
Giesen et al[27]	Pre 3.1 kg Post 5.5 kg	Pre 10.1 kg Post 13.4 kg	Pre 8.5 Post 9.3	At rest pre 5 post 2.0 Light tasks pre 7.5 post 5.0 Hard tasks pre 10 post 6.0

Post, postoperative; pre, preoperative.

*The values represent the percentage of study population that experienced unquantified improvements in a specific category after denervation.

†The values represent improvements in postoperative outcomes relative to preoperative outcomes.

surgical approach may be rooted, in part, in differing preoperative workups among authors. Preoperative diagnostic nerve blocks to identify joint innervation were used by only 3 of the 9 studies, with unclear effects on denervation efficacy. Additionally, the use of radiologic classification scores as exclusion criteria

TABLE 5. Patient Complications, Time to Return to Work, and Follow-Up Time After Surgery, as Reported by Individual Studies

First Author	Complications	Recovery	Follow-Up (months)
Tuffaha et al[19]	1 (8.3) of 12 cases underwent revision LRTI (for persistent pain) 8 of the 12 cases had patchy numbness 1 of the 12 cases had pain that resolved after a steroid injection	6/7 pts <6.5	15.3 (2.5)
Giannikas et al[20]	No revisions 1 of 15 had "poor improvement" 2 of 15 were lost to FU		24
Salibi et al[21]	9 (25.7%) of 35 cases underwent trapeziectomy revision (reasons for revisions not listed)		60
Arenas-Prat[22]	No revisions 2 of 16 had a hypertrophic scar 1 of 16 had permanent dorsoradial thumb hypotheshesia		15
Loréa[16]	No revisions Radial nerve paresthesias in most cases (assumed in at least 8 of 14 cases) All radial nerve paresthesias were transient		8
Dellon[23]	No revisions, no complications (0 of 5 cases)		125.6
Donato et al[24]	0 of 11 cases underwent revision 1 of 11 cases underwent postop infection 1 of 11 cases had persistent pain (no revision desired)		>6
Ehrl et al[25]	No revisions 1 of 42 had wound infection 1 of 42 had CRPS type 1		52 (24.7)
Giesen et al[27]	No revisions 3 of 24 cases had SBRN paresthesias (self-resolved) 1 of 24 had neuropathic pain SBRN (mild, persistent) 1 of 24 had synovitis FCR (resolved after orthosis fabrication)	2.5 (2−4.5)	>12

CRPS, chronic regional pain syndrome; FCR, flexor carpi radialis; FU, follow-up; postop, postoperative; pts, patients; SBRN, superficial branch of the radial nerve.

by a study is questionable because these have been shown to have an inconsistent correlation with clinical symptoms.[10,25] A systematic preoperative diagnostic methodology and clearer inclusion or exclusion criteria based on clinical symptoms could lead to more consistent denervation techniques and surgical indications.

A limitation of our systematic review is the inability to aggregate outcomes, given the inconsistent reporting by individual studies. Based on the limited clinical outcomes reported, denervation appears to be well tolerated, with 7 of the 9 studies reporting no revisions in at least the short-term postoperative follow-up period.

With only 1 prospective clinical trial performed to date, the main challenge that confronts the future implementation of denervation is the lack of long-term follow-up data and comparisons with other approaches to treatment.[10,21] Once long-term revision rates are better characterized, patients and surgeons can make more informed decisions on the use of denervation as a permanent or temporizing procedure. The theoretical potential for Charcot joint formation due to the lack of sensory input must be considered, although it has not been observed in any studies related to joint denervation.[28,29] Along these lines, neural circuits between first CMC ligaments and the surrounding muscles have been shown to facilitate coordinated ligamentomuscular reflexes that may stabilize the joint in high-load-bearing scenarios, such as tip pinch, and protect against joint degradation.[30] Whether the loss of neural input into these neural circuits may put patients undergoing denervation at higher risk of OA acceleration or joint instability remains unknown without longer-term follow-up.

Carpometacarpal denervation is an emerging method of treating first CMC joint arthritis, with positive results in the limited studies conducted to date. Further investigation of effective preoperative testing and the standardization of denervation techniques may be useful in making postoperative results more predictable.

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