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ORIGINAL ARTICLE

Basal joint arthroplasty and carpal tunnel release comparing a single versus double incision: a prospective randomized study

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Abstract

Purpose Basal thumb joint osteoarthritis frequently coexists with carpal tunnel syndrome. The two conditions have traditionally been treated surgically through separate incisions. We sought to determine whether carpal tunnel release using a single incision during basal joint arthroplasty is as effective as a two-incision approach in patients with concomitant carpal tunnel syndrome and basal thumb joint osteoarthritis.

Methods For this purpose, 40 patients were randomly allocated to either a single-incision or double-incision approach, all of whom completed the full follow-up period. The Boston Carpal Tunnel Questionnaire, QuickDASH, and a 10-point visual analog scale pain-severity rating were obtained from patients 3, 6 and 12 months post-operatively.

Results The two treatment groups experienced comparable, progressive improvement in all symptom-, function-, and pain-related outcomes, with mean surgery time significantly shorter with the single-incision approach, and four versus zero patients in the double-incision group developing pillar pain ($p = 0.035$).

Conclusions Concomitant basal thumb joint osteoarthritis and carpal tunnel syndrome might be effectively performed through a single-incision approach, potentially avoiding any morbidity classically associated with a second incision.

Level of evidence Level II/Therapeutic Study.

Trial registration ClinicalTrials.gov: NCT04391751, 04/29/2020, retrospectively registered.

Keywords Basal joint arthroplasty · Carpal tunnel release · Single approach · Double approach

Introduction

Basal thumb joint osteoarthritis is a common disorder, especially among postmenopausal women. In this specific subgroup of patients, radiographic signs appear in up to 40% [1]. Approximately 28% of these patients are symptomatic [2]. The patho-anatomy and treatment of basal thumb joint osteoarthritis (OA) have been well described [3–7]. The trapeziometacarpal joint is the joint that most commonly requires treatment for OA in the upper extremity, and this often involves removing the trapezium [8].

This same demographic group is also frequently affected by carpal tunnel syndrome (CTS), which coexists with basal joint OA in 18–46% of patients [9–11]. In these patients, a combined surgical approach has been reported to be beneficial [12, 13]. The two conditions have traditionally been treated surgically through separate incisions: a dorso-radial incision for the trapeziectomy and standard midline volar carpal tunnel incision for median nerve decompression [9, 14, 15]. Though the trapeziectomy procedure has been proven to provide some degree of carpal tunnel decompression [12], previous study result suggests that releasing the transverse carpal ligament (TCL) should be performed in addition to a basal joint arthroplasty incision, as a trapeziectomy, by itself, fails to completely decompress the carpal tunnel [16, 17].

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The ability to decompress the carpal tunnel during basal joint arthroplasty using a single incision would likely shorten surgery time, improve aesthetics, and potentially decrease morbidity compared to a staged or two-incision procedure [18]. To date, the only papers published on this issue have been in vitro or small series of 11 patients or less [16, 18]. To our knowledge, the present study is the first to compare these two techniques directly.

Our ultimate research goal is to determine whether carpal tunnel release (CTR) using a single incision during basal joint arthroplasty is as effective as a two-incision approach in patients with concomitant CTS and basal thumb joint OA in the context of a prospective randomized study. A secondary objective was to identify any potential effect of a single incision versus two incisions in terms of preventing some of the problems and morbidity typically associated with the second incision, like pillar pain (pain between the thenar and hypothenar areas of the hand), prolonged surgical time, wound infection, and necrosis of the skin bridge between the two incisions.

Methods

We performed a single-center prospective randomized study that compared the surgical treatment of CTR during basal joint arthroplasty using a single-incision versus double-incision approach. The study was conducted between March 2017 and June 2019. 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. Informed consent was obtained from all patients for being included in the study. The study was registered at ClinicalTrials.gov (NCT04391751). Prior to data collection, local ethics committee approval was obtained (PR(ATR)147/2018). The manuscript was written following Consolidated Standards of Reporting Trials (CONSORT) guidelines.

To be eligible for the study, patients needed to be scheduled for surgical treatment of both primary basal joint osteoarthritis and CTS in the ipsilateral extremity. Surgery for CTS was considered when symptoms were severe enough to either awaken the patient at night or impede daily living activities, and when positive physical examination findings (e.g., Phalen's or Tinel's test) and electrodiagnostic testing (EDT) results supported the diagnosis of CTS, the latter of these performed in all patients. The severity of CTS was classified as mild, moderate, or severe, based upon the sensory conduction rate observed on EDT and motor distal latency distance, as follows: (1) mild = a slow orthodromic sensory conduction rate (< 46 m/s), but normal motor distal latency; (2) moderate = a slow sensory conduction rate (< 46 m/s) but motor distal latency of more than 4.0 ms; (3) severe = extended or lost motor distal latency and the potential loss of a sensory nerve axon.

Basal joint arthritis surgery was proposed when OA severity was radiographically identified as Eaton stage II or greater and the patient reported unacceptably severe pain, localized to the basal joint, that appeared either with activity or was reproduced by either the grind test or direct palpation, as long as previous nonsurgical treatment had failed (e.g., use of an orthosis, anti-inflammatory medication, physical therapy and/or corticosteroid injections). Patients with comorbid etiological factors predisposing them to CTS—like diabetes mellitus, acute trauma, rheumatoid arthritis, pregnancy, hypothyroidism, and hyperthyroidism—were excluded from the study. Likewise, patients who presented with post-traumatic arthritis, previous hand surgery procedures that could have altered carpal tunnel anatomy, nerve compression at a more proximal level, or other upper limb nerve entrapment were excluded.

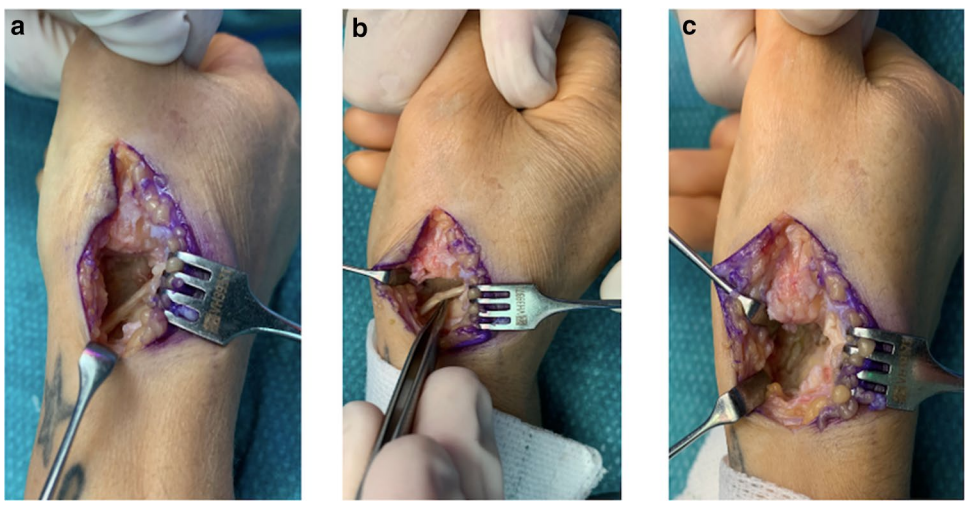

Fig. 1 Carpal tunnel release through dorsal incision. **a** Once trapeziectomy is performed, **b** flexor carpi radialis is retracted in a volar direction, allowing carpal tunnel release. **c** Visualization of flexor pollicis longus tendon indicates complete release

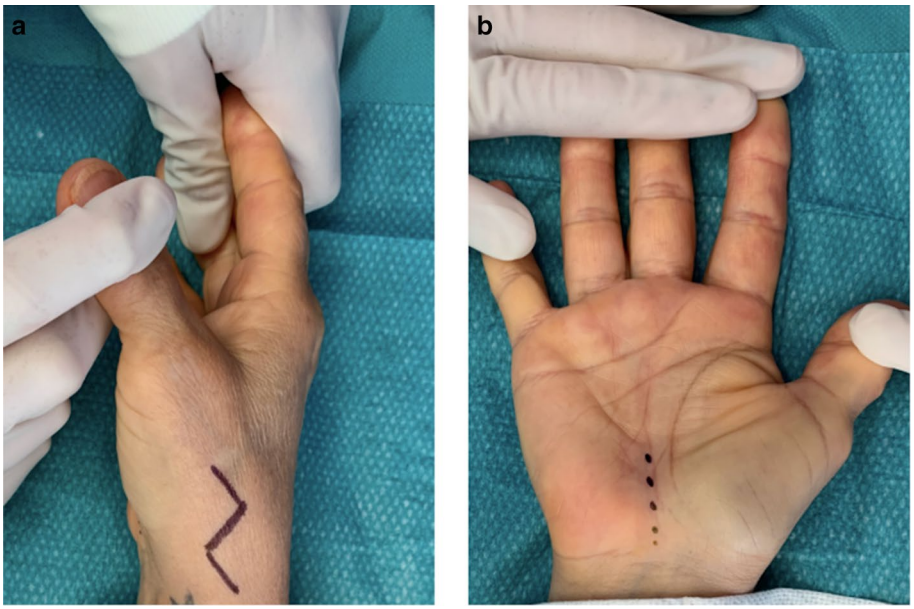

Fig. 2 Double-incision approach for concomitant carpal tunnel syndrome and basal joint osteoarthritis surgery: **a** dorsal approach for trapeziectomy and **b** volar approach for carpal tunnel release

Forty patients were enrolled into the study, all of whom completed the full follow-up period. After informed consent had been obtained from all patients, they were randomly allocated for treatment with either CTR during basal joint arthroplasty using a single incision (Group I) or CTR during basal joint arthroplasty using a double-incision approach (Group II). We adopted a simple randomization method with an allocation ratio of 1:1. A computer-generated random-numbers table was used. All surgeries were performed by the same surgeon.

Surgical technique

Group I

The surgical technique chosen for thumb basal join was a trapeziectomy with ligamentous reconstruction and tendon interposition (LRTI), using the flexor carpi radialis (FCR), as described by Burton and Pellegrini [4]. Through a dorsal approach over the trapeziometacarpal joint, and while avoiding injury to the superficial branch of the radial sensory nerve and radial artery, the entire trapezium was excised. Attention was paid during trapezium excision not to damage the FCR tendon. Volar traction of the FCR allowed us to longitudinally incise the deep leaflet of the FCR tendon until the flexor pollicis longus (FPL) tendon was clearly visualized, thereby releasing the carpal tunnel (Fig. 1). At that point, to ensure complete release, the surgeon's gloved finger or dissecting scissor was inserted. Then, the ulnar half of the FCR tendon was harvested proximally through a second transverse incision in the middle third of the forearm and split all the way to its insertion on the index metacarpal. A hole was drilled into the base of the first metacarpal. Then the FCR tendon was routed through the bone tunnel and fixed with non-re-absorbable sutures. Finally, the remaining tendon was rolled up and placed in the trapezial void to provide inter-positioning.

Group II

Trapezial excision and ligament reconstruction were performed in the same way as in Group I, except that the FCR deep leaflet was not incised. After radial incision wound closure, CTR was performed through a second separate longitudinal palmar incision (Fig. 2).

Post-operative care and follow-up

After surgery, the wrist and metacarpophalangeal thumb joint were immobilized in a spica plaster cast for two weeks. A removable orthosis was then used for the next four to six weeks, during which the patient was instructed to perform active range of motion (ROM) exercises. Eight weeks after surgery, strengthening exercises and using the hand for daily activities were allowed.

Assessments

The study protocol required an examination before surgery and at 2 and 6 weeks, and 3, 6 and 12 months postoperatively. Each evaluation involved the patient completing a set of questionnaires and undergoing a clinical assessment. The same independent evaluator carried out all the assessments.

Preoperatively, patient demographics (age and sex), comorbid conditions, dominant hand, and occupation were recorded. The baseline clinical assessment included a targeted history and physical examination (patient symptoms, Tinel's test, Phalen's test, grind test), EDT and preoperative radiographs.

Grip strength was measured preoperatively and at 3, 6 and 12 months, recorded as the mean of three attempts, in kilograms, adjusted for hand dominance, using a standard dynamometer (Jamar Dynamometer; Jackson, Missouri). Data related to the surgery (date, side of hand operated on, duration of the surgical procedure (in minutes), and postoperative complications) and the mean time to return to work or regular activities also were collected. Among complications, pillar pain, understood as pain between the thenar and hypothenar areas of the hand after CTR, was assessed using the "table test" [19].

To assess CTS symptom intensity, patients filled out the Spanish-language version of the Boston Carpal Tunnel Questionnaire (BCTQ) [20], with each item rated from 1 = no complaints to 5 = maximum severity of complaints possible. The BCTQ covers two domains, with both a symptom severity scale (SSS) and functional status scale (FSS), having 11 and 8 items, respectively. Hand function and pain were evaluated using Quick Disabilities of the Arm, Shoulder, and Hand (QuickDASH) scores [21] (0 = no disability; 100 = total disability) and a 10-unit visual analog scale (VAS) [22] (0 = no pain, 10 = maximum pain), respectively. All these scores were calculated at baseline and at 3, 6 and 12 months after surgery.

Statistical analysis

Categorical variables were reported as absolute numbers and percentages, while continuous variables were summarized as medians with interquartile ranges, or means and standard deviations (SD), as appropriate. Comparative analyses were performed with Pearson $\chi 2$ or Fisher's exact test for categorical variables, as appropriate, and with Student's t test or the Mann–Whitney U test for continuous variables; again, as appropriate. Note that the outcome main comparisons of interest were changes in outcome measures between the groups (intergroup) and opposed to changes versus baseline (intra-group). All statistical tests were 2-tailed, and the criterion for statistical significance was set as $p < 0.05$.

During study design, a sample size calculation, assuming an α-error of 0.025 and a β-error of 0.1 (power of 0.9), resulted in a sample deemed too large to consider. As no other comparative studies on this field had been previously published, and assuming an underpowered study, sample size was reduced to 40 patients in order to perform a preliminary study, which eventually might be enlarged.

Results

Forty patients were randomized equally into the two treatment groups. The single-incision group was composed of 16 females and 4 males, with a mean age of 61.5 years (SD 6.9), while the double-incision group was formed by 17 females and 3 males, with a mean age of 58.5 years (SD 6.2). Preoperatively, no differences between the two groups were found in whether the dominant or non-dominant hand was involved, or in EMG values, Eaton stage, BCTQ score, Quick-DASH score, or VAS pain severity rating (Table 1).

All the outcome variables exhibited statistically significant progressive improvement throughout the observation period in both treatment groups, including reductions from baseline to 3 months, 3 months to 6 months, and 6 months to 12 months follow-up (Table 2). Specifically comparing the final follow-up assessment against baseline, in the single-incision group, the BCTQ score decreased from 54 (37–64) preoperatively to 24.7 (18–32) at 12-month follow up, a mean reduction of 29.3. In the double-incision group, it decreased from 53.8 (41–79) to 25.2 (21–30), a difference of 28.6. These two differences were not statistically different ($p = 0.74$). Mean differences between baseline and final follow-up in the single- versus dual-incision group were -19.1 and −20.0 for the Quick-DASH (p for difference in change from baseline = 0.20), + 5.9 and + 6.5 for grip strength (relative increases of 18.5 and 22.2%, $p = 0.47$), and −5.6 and −5.1 for VAS pain-severity rating ($p = 0.11$), respectively. Final grip strength at 12-month follow-up in the single-incision group was 31.5 versus 29.0 in double-incision group (NS).

Mean surgery time was significantly shorter in patients in the single-incision (49.5 [range 41–61] minutes) versus double-incision (58.3 [range 41–75] minutes) group

Table 1 Baseline characteristics of single-incision and double-incision groups

Variable	Single-incision group ($n = 20$)	Double-incision group ($n = 20$)
Male:female ratio	4:16	3:17
Age, years (mean ± SD)	61.5 ± 6.877	58.45 ± 6.219
Eaton stage of OA[†] (median [range])	3 (2–4)	3 (2–4)
Dominant hand operated on, *n* (%)	9 (45)	12 (60)

[†]OA, osteoarthritis

Table 2 Comparison of the different outcome variables throughout the follow-up period

Outcome measurement	Baseline			3-month Follow-up			6-month Follow-up			1-year Follow-up		
	Single-incision group ($n=20$)	Double-incision group ($n=20$)	p-value	Single-incision group ($n=20$)	Double-incision group ($n=20$)	p-value	Single-incision group ($n=20$)	Double-incision group ($n=20$)	p-value	Single-incision group ($n=20$)	Double-incision group ($n=20$)	p-value
BCTQ† (mean ± SD)	54 (7.61)	53.8 (9.76)	0.481	35 (8.033)	35.1 (6.973)	0.892	29.4 (6.099)	29.5 (4.718)	0.989	24.7 (4.256)	25.2 (2.707)	0.744
Quick-DASH‡ (mean ± SD)	34.7 (5.97)	34.5 (4.19)	0.724	22.35 (6.192)	24.9 (6.672)	0.226	19 (4.69)	18.7 (4.079)	0.849	15.6 (3.185)	14.45 (2.235)	0.197
Grip Strength, Kg (mean ± SD)	25.55 (12.51)	22.5 (11.062)	0.385	21.5 (9.473)	20.75 (7.304)	0.943	28.5 (1.526)	27.75 (11.525)	0.824	31.45 (10.904)	29 (10.712)	0.470
10-VAS¶	7.4 (0.598)	7.4 (0.598)	1.000	3.7 (1.218)	4.1 (1.165)	0.385	2.25 (0.716)	2.8 (1.056)	0.080	1.83 (0.857)	2.25 (0.851)	0.110

†BCTQ Boston Carpal Tunnel Questionnaire; ‡QuickDASH, Quick Disabilities of the Arm, Shoulder, and Hand; ¶10–VAS, 10–unit visual analog scale

($P<0.02$). Four out of 20 patients in the double-incision group developed pillar pain versus no single-incision patients ($p=0.035$). One patient in each treatment group had temporary paresthesia in the territory of the superficial sensory branch of the radial nerve. A second CTR was successfully performed in one patient in the double-incision group, due to only partial CTS relief after the first procedure. No other complications were reported.

Discussion

In this prospective randomized study, we observed steady improvement in all four outcomes across the three post-operative data-collection points in both treatment groups. Though no inter-group differences were statistically significant, for two of the outcomes—the BCTQ score and pain severity—the magnitude of change was greater with the single-incision group. Overall, patients' pain severity decreased by 75.7 and 68.9% in the single- versus dual-incision groups, both highly satisfactory results. For the other two outcomes—the QuickDASH score and grip strength—the dual-incision group slightly outperformed the single-incision approach; but again, both differences fell well short of statistical significance. Moreover, though the change in grip strength was slightly greater in the dual-incision group, patients who underwent the single-incision procedure ultimately exhibited 2.5 kg greater grip strength at final follow-up. The former procedure also shaved almost nine minutes off surgery time, a 15% reduction, meaning that one additional procedure (8 versus 7) could be performed within every seven-hour period of operating time, with an additional 12 min to spare.

With respect to complications, a statistically significant difference in the two groups was observed, with zero versus 20% of patients in the single- versus dual-incision groups reporting pillar pain post-operatively ($p=0.035$). Transient paresthesia in the territory of the superficial sensory branch of the radial nerve was the only other complication observed, occurring in just one patient per treatment group. Pillar pain is an issue that warrants consideration, given that it is the most commonly reported complication after CTR, affecting from 6 to 36% of patients [23]. In the current study, four patients in the double-incision group developed pillar pain that lasted a mean 3.2 months post-operatively. The single-incision approach theoretically avoids this complication.

Further justification of this study stems from published literature, in that carpal tunnel syndrome and thumb OA commonly coexist. Published studies also indicate that performing carpal tunnel release and a trapeziectomy during the same operation is beneficial, albeit traditionally performed through separate incisions [12, 13]. Previous studies have shown that carpal tunnel pressures decrease after a

trapeziectomy. However, trapeziectomy alone with no additional release of the TCL is insufficient to fully decompress the carpal tunnel [16, 17]. Cassidy et al. [16], in a cadaveric study, described performing CTR during basal joint arthroplasty using a single incision as an effective way to decompress the carpal tunnel. Ingari and Romeo [18] subsequently published excellent results in 11 patients who underwent radial-sided carpal tunnel release and basal joint arthroplasty through a single incision. To our knowledge, the current study is the first to compare the results of concomitant CTR and basal joint arthroplasty using one versus two incisions.

Interpretation of our results warrants caution, given this study's limitations. Despite randomized and controlled, our study is underpowered. Calculating the sample sizes required to detect statistically significant differences in pain reduction and grip strength increase yielded treatment group sizes (n-98 and $n = 112$ per group, respectively) both within the realm of a multi-center study. On the other hand, the difference in the BCTQ score from baseline to one-year follow-up was virtually identical in the two groups—with reduced scores of 29.3 and 28.6 in the single- versus double-incision group, respectively—suggesting that even a much larger study would have been unlikely to detect any clinically meaningful or statistically significant advantage of one approach over the other. Longer follow-up also is recommended to determine whether gains achieved over the first post-operative year are sustained more long-term. Finally, the clinical examiner was unblinded to treatment arm, which might have influenced patients' responses on follow-up.

Our results clearly must be considered encouraging, with respect to the potential use of single-incision surgery as an alternative to dual-incision surgery when combining CTR and trapeziectomy, avoiding any morbidity classically associated with a second incision as well as shortening the surgery time. They also show that a larger prospective randomized study comparing these two approaches is both justified and feasible, albeit likely as a multi-center study.

Author's contributions IE-F and IG-C researched literature and conceived the study. ALL-B was involved in protocol development and NV in gaining ethical approval. SB-O and XM were involved in patient recruitment and data analysis. IE-F and IG-C wrote the first draft of the manuscript. All authors reviewed and edited the manuscript and approved the final version of the manuscript.

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Declarations

Conflicts of interest The authors have no relevant financial or non-financial interests to disclose. The authors have no conflicts of interest to declare that are relevant to the content of this article. All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript. The authors have no financial or proprietary interests in any material discussed in this article.

Availability of data and material The authors certify that all data and materials support their published claims and comply with field standards.

Code availability The authors certify that software application support their published claims and comply with field standards.

Ethics approval Ethical approval for this study was obtained from COMITÉ DE ÉTICA DE INVESTIGACIÓN CLÍNICA (CEIC) DEL HOSPITAL UNIVERSITARI VALL D'HEBRON (PR(ATR)147/2018).

Consent to participate Informed consent to participate was obtained from all individuals participants included in the study.

Consent for publication Informed consent for publication was obtained from all individuals participants included in the study.

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