Radial Column Excision and Four-Corner Fusion for the Treatment of Basal Thumb Arthritis and Scapholunate Advanced Collapse Wrist or Midcarpal Arthritis

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Abstract

Background The combination of trapeziometacarpal arthritis and intercarpal pattern of degenerative wrist arthritis is uncommon.

Purpose To report on the clinical and radiologic results of patients who have undergone radial column excision (scaphoidectomy and trapeziectomy) (RCE) and four-corner fusion (4CF). We describe the patterns of disease that present with basal thumb and midcarpal arthritis and treatment outcomes of a single-surgeon series.

Patients and Methods A consecutive series of seven patients underwent RCE and 4CF over a 2-year period, for basal thumb osteoarthritis with concurrent degenerative midcarpal wrist arthritis. Six patients were available for review. All six patients were women with a mean age of 73 years (range: 67–78; SD 4.6). Mean follow-up time was 48.2 months (34–59 months). Radiographic and clinical outcomes were recorded for all patients, to include wrist range of motion, key pinch, grip strength, and patient-rated wrist evaluation (PRWE).

Results There were no failures or revision procedures. The mean range of motion was flexion of 40 degrees (range: 30–40 degrees), extension of 30 degrees (range: 20–42 degrees), radial deviation of 18 degrees (range: 10–30 degrees), and ulnar deviation of 15 degrees (range: 0–25 degrees). The mean key pinch was 4.2 kg (range: 0.5–10, SD $\pm$ 3.5) and mean grip strength was 9.4 kg (range: 0–19, SD $\pm$ 8.9). The PRWE results in four patients were within normal values.

Conclusion RCE with 4CF resulted in acceptable clinical outcomes in four of six patients treated, with no failures at a mean follow-up of 48.2 months.

Level of Evidence Level IV, therapeutic study.

Keywords

- basal thumb arthritis
- four-corner fusion
- limited wrist arthrodesis
- partial wrist fusion
- midcarpal arthritis
- trapeziometacarpal arthritis

Basal thumb arthritis involving the trapeziometacarpal (TM) or the scaphotrapezotrapezoidal (STT) joint is a common presentation in postmenopausal women.^{1–3} The combination of TM or pantrapezial arthritis together with an asso-

ciated intercarpal or radiocarpal pattern of degenerative wrist arthritis is less well described. Ferris et al⁴ reported on a series of 697 wrists and found a significant association between STT osteoarthritis and static dorsal intercalated

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Table 1 Demographic data

Case	Sex	Age at surgery	Side	Follow-up (mo)	Staged	Arthritic pattern	Eaton stage
1	Female	70	Left	36	2-stage	CIND	4
2	Female	77	Right	56	2-stage	CIND	— ^a
3	Female	75	Left	48	1-stage	Chondrocalcinosis	4
4	Female	71	Right	34	1-stage	SLAC-3	4
5	Female	78	Right	59	1-stage	SLAC-3	4
6	Female	67	Left	56	1-stage	CIND	4

Abbreviations: CIND, carpal instability nondissociative; SLAC, scapholunate advanced collapse.

^aPatient had a previous titanium CMC replacement requiring trapeziectomy with no prior X-rays available.

instability (DISI). The prevalence of this combination was found to be 2.3%. Brunelli and Brunelli⁵ observed that the STT ligaments provide stability to the scaphoid in preventing rotary subluxation. Removal of the trapezium can lead to carpal collapse by either a dissociative or nondissociative pattern depending on the state of the scapholunate (SL) ligament.²

The rationale for the combination of trapeziectomy and four-corner fusion (4CF) is to combine two independently effective procedures in patients who have combined basal thumb and midcarpal pathology.

The purpose of this study was to report on the clinical and radiologic results of radial column excision (RCE) with 4CF. We describe the patterns of disease and treatment outcomes of a single-surgeon series of patients. We hypothesize that this combined treatment offers acceptable hand and wrist function.

Patients and Methods

Patients

Institutional ethics approval was obtained from St. Vincent's Hospital Melbourne Human Research Ethics Committee, to retrospectively review a series of patients who underwent RCE and 4CF, treated by the senior author between January 2010 and December 2011. Patients were identified and included in the study by performing a search of scaphoidectomy with limited wrist arthrodesis (LWA) and those that also underwent trapeziectomy and ligament reconstruction tendon interposition (LRTI). Demographic data, presenting complaint, and type of surgical intervention and any subsequent procedures were recorded. Independent assessment of radiographic and clinical outcomes was performed to minimize bias.

Seven patients underwent RCE and 4CF over a 2-year period for basal thumb osteoarthritis with degenerative radiocarpal or midcarpal arthritis. One patient died of unrelated cause, which left six patients available for follow-up. Procedures were staged in two of six cases and as a single stage in four cases. All six patients were women with a mean age of 73 years (range: 67–78 years; standard deviation [SD] 4.6 years) at the time of surgery. Mean follow-up time was 48.2 months (34–59 months) (—Table 1).

Patients underwent single-stage RCE and 4CF where there was clinical and radiologic presentation of symptomatic basal thumb and wrist or midcarpal arthritis without arthritis of the radiolunate (RL) joint (—Fig. 1). Two patients underwent a two-stage procedure. One patient developed symptomatic arthritis of the lunocapitate joint associated with a nondissociative DISI 12 months after trapeziectomy. One other patient underwent trapeziectomy after a failed trapezium replacement and symptomatic arthritis of the lunocapitate joint associated with a nondissociative DISI 11 years after the trapeziectomy (—Fig. 2A, B).

Surgical Technique

The surgical technique for trapeziectomy and LRTI is similar to that described by Burton and Pellegrini⁶ using approximately one-third of the flexor carpi radialis tendon passed

Fig. 1 Arthritis involving the trapeziometacarpal, scaphotrapezial, radioscaphoid, and lunocapitate joints associated with scapholunate disruption.

Fig. 2 (A) Radiograph showing lunocapitate arthritis, 11 years after trapeziectomy. (B) Lateral radiograph showing extended lunate and scaphoid (nondissociative DISI) and lunocapitate arthritis.

through a drill hole at the base of the first metacarpal. No Kirschner wire was used.

The technique for 4CF has been described previously.⁷ A posterior interosseous neurectomy is routinely performed. Attention is made to preserving the radioscapophcapitate ligament and correcting the lunocapitate alignment. Distal radius bone graft is used in all cases, and fixation of the lunate, triquetrum, capitate, and hamate is with a circular locking plate. No radial styloidectomy is performed as the trapezium was excised. In the immediate postoperative period, the wrist is placed in a long-arm cast including the thumb for 2 weeks and then fitted with a thermoplastic splint with the wrist in 20-degree extension at which time active mobilization of the thumb and wrist is commenced. Follow-up radiograph of the wrist is performed at 6 weeks, and passive exercises are instituted if there is satisfactory evidence of midcarpal fusion. A repeat radiograph is performed at 12 weeks. Thumb key pinch exercises commence at 6 weeks depending on symptoms. Routine follow-up is performed at 2, 6, and 12 weeks and 6 months.

Radiographic Review

Pre- and postoperative posterior-anterior and lateral radiographs were reviewed, and the following radiographic assessments made:

1. Eaton stage of TM osteoarthritis
2. Modified carpal height ratio
3. Preoperative carpal alignment
 - a. RL angle
 - b. Radioscaphoid (RS) angle
 - c. SL angle
4. Pattern of wrist arthritis
5. Postoperative radiographic signs of fusion
6. Postoperative assessment of RL joint space

Staging of TM arthritis was documented according to the Eaton classification.⁸ The modified carpal height ratio was used to assess preoperative carpal height and collapse as described by Nattrass et al.⁹ Measurement of trapezial height cavity has previously been described by Goffin and Saffar¹⁰ using an absolute number value, and by Downing and Davis¹¹ using a ratio of trapezial height to length of thumb proximal phalanx. Both methods could not be used to evaluate the degree of thumb metacarpal proximal migration as the scaphoid had been resected and remaining carpus fused. Carpal angles were measured using the tangential method described by Larsen et al¹² on a lateral radiograph. DISI was defined as 10 degrees of lunate extension in reference to the long axis of the radius with the wrist in neutral flexion/extension and pronation/supination. Carpal height and SL angle were used to confirm the pattern of carpal instability. Follow-up radiograph was performed at review to assess for union of the fusion mass and RL joint space.

Clinical Outcomes

Patient outcomes in this series are reported with a functional outcome assessment using the patient-rated wrist evaluation (PRWE),¹³ a 15-point questionnaire that equally rates pain and disability in functional activities. Scoring is done on an 11-point scale (0–10) with 0 being no difficulty or pain and 10 being most difficult to perform or severe pain. There are three subscales, pain, specific-activities, and usual activities, which form a total score of 100, with equal weighting for pain and disability. Objective assessment of wrist range of motion, grip strength (kg), and key pinch strength (kg) was made.

Statistical Methods

Quantitative results are reported as means and standard deviation of each variable. Categorical variables are reported for each case as descriptive analyses.

Results

Preoperative radiographic analysis showed two patients with nondissociative DISI and lunocapitate arthritis following trapeziectomy (►Fig. 2A, B), one patient with pantrapezial and lunocapitate arthritis associated with SL dissociation and chondrocalcinosis of the triangular fibrocartilage (TFC) without arthritis of the scaphoid fossa (►Fig. 3), two patients with pantrapezial arthritis and a scapholunate advanced collapse 3 (SLAC-3) pattern of wrist arthritis, and one patient with pantrapezial arthritis associated with nondissociative DISI deformity and lunocapitate osteoarthritis (►Fig. 4A, B). All patients achieved radiographic union, and there was no progression of RL arthritis or screw loosening. The mean wrist range of motion was flexion of 37.9 degrees (range: 30–45, SD $\pm$ 4.9), extension of 29.6 degrees (range: 20–42; SD $\pm$ 7.3), radial deviation of 18.3 degrees (range: 10–30; SD $\pm$ 8.2), and ulnar deviation of 12.5 degrees (range: 0–25; SD $\pm$ 10.4). The mean key pinch was 4.2 kg (range: 0.5–4.3; SD $\pm$ 3.5) and mean grip strength was 9.4 kg (range: 0–19, SD $\pm$ 8.9) (►Table 2). PRWE (►Table 3) analysis showed mean pain scores of 22.6/50 (range: 10.5–45; SD $\pm$ 12.3), mean function scores of 16.4/50 (SD 17.3; range: 0–44), and a mean total score of 39.0/100 (range: 10.5–65; SD $\pm$ 29.1). Four patients had a satisfactory outcome from PRWE outcome criteria (►Table 3). RL angles (►Table 4) were corrected from a mean of 18.9 degrees (range: 7.3–19.4; SD $\pm$ 10.7) to 6.4 degrees (range: 1.2–9.3; SD $\pm$ 3.3). No complications were observed. There were no failures or revision procedures.

Fig. 3 Radiograph showing pantrapezial and lunocapitate arthritis associated with scapholunate disruption and chondrocalcinosis of the triangular fibrocartilage.

Discussion

Basal thumb arthritis or STT arthritis is not commonly associated with intercarpal or radiocarpal degeneration. Basal thumb arthritis is successfully treated with trapeziectomy alone or in conjunction with LRTI.¹⁴ Similarly, wrist degenerative arthritis associated with chronic SL dissociation or scaphoid nonunion can be successfully treated by limited wrist fusion.^{7,15} However, basal thumb arthritis with wrist arthritis is an uncommon combination.

Waitzenegger et al¹⁶ recently discussed the treatment of patients with basal thumb and wrist arthritis. The basal thumb arthritis of their patient cohort was treated by either trapeziectomy or TM replacement arthroplasty and their wrist arthritis by either proximal row carpectomy or 4CF. The rationale for this study, using a combination of trapeziectomy and 4CF, is to combine two independently effective procedures in patients who have combined basal thumb and midcarpal pathology. Our patient cohort was treated by RCE, excising both the trapezium and scaphoid, and 4CF. The theoretical concern is that of thumb metacarpal collapse, resulting in poor hand and wrist function. The medium-term outcomes presented in this case series demonstrate acceptable radiographic and clinical outcomes following a combination of RCE with LRTI and 4CF.

The clinical outcomes of our patient cohort can be compared with normative data¹⁷ (►Figs. 5 and 6). We used a comparable group of age 50- to 65-year-old women in nonmanual occupation. We found this group most closely represented the demographics of our patient cohort. In all cases, the range of radial deviation was within the range for age-matched controls. However, wrist flexion, extension, and ulnar deviation were decreased relative to age-matched controls (►Table 2). Percentage values have been calculated by comparing our data to that of Klum's normative data as a control population. Mean range of motion, compared with population controls, shows preservation of 60.4% flexion, 54.6% extension, 28.3% of ulnar deviation, and 104% of radial deviation.

Most studies reporting on the mid- to long-term outcomes of 4CF are in younger male patients.^{15,18–20} Klum et al¹⁷ identified significant differences in grip strength and range of motion with age and sex. Demographic differences need to be taken into account. The range of motion of the wrists after RCE and 4CF was compared favorably with those after 4CF¹⁵ (►Table 2). The mean radial deviation of these wrists was increased and is likely a result of trapeziectomy.

We expected a notable loss of both key pinch and grip strength after excision of the radial column, but our patients had a comparable mean key pinch but reduced grip strength (►Table 2).

PRWE is a validated tool¹³ that provides a numerical measure of patient reported clinical outcome. It can be converted to a DASH (Disabilities of the Arm, Shoulder and Hand) value by $DASH = 0.81 + 0.81 \times PRWE$, and normal function measured by DASH has been assigned a value of 13 (SD $\pm$ 15.0).²¹ The median quick DASH in one study¹⁵ after

Fig. 4 (A) Radiograph showing basal thumb arthritis with no evidence of scapholunate dissociation. (B) CT scan showing DISI and lunocapitate arthritis.

4CF has been reported as 37.4 (+/- 26.3) and in another long-term study as 20.4.²⁰ Following LRTI, after a mean follow-up of 10.1 years, a mean quick DASH of 29 (+/- 28) has been reported.²² Four patients in our series (►Table 3), who underwent a single-stage RCE and 4CF, had a calculated DASH score of ≤25.4. It was comparable to those reported after 4CF^{15,20} or trapeziectomy and LRTI.²² Both patients who underwent an initial trapeziectomy and subsequent scaphoid excision and 4CF had poor function scores with calculated DASH of 47.4 and 72.9. The radiograph of one patient showed some prominence of the circular fixation plate. There was no radiographic progression of RL joint arthritis or thumb metacarpal impingement to the second carpometacarpal joint or to the radial styloid.

In contrast to Waitzenegger et al,¹⁶ we have not retained the distal pole of scaphoid for fusion to the capitate to provide support for the thumb metacarpal. In these cases in which there is both pan trapezial arthritis and wrist arthritis, an LRTI technique may be necessary after excision of the radial column.

The small number of patients presenting with these combined pathologies makes it difficult to draw any subgroup analyses of correlation between PRWE, objective outcome measures, and radiographic outcomes. The limitations of a retrospective study with incomplete preoperative range of motion, strength testing, or PRWE scores do not allow comparisons of preoperative impairment to their follow-up measurements. We were unable to use the nonoperated

Table 2 A comparison of clinical outcomes following RCE and 4CF with 4CF, trapeziectomy, and normative data

Parameter	Current study RCE mean (SD)	Trail et al ¹⁵ 4CF mean (SD)	Gangopadhyay et al ¹⁴ Trapeziectomy + LRTI median (range)	Klum et al ¹⁷ Normative mean (SD)
Wrist flexion	38 (4.9)	32.5 (15.4)	–	62.9 (12.6)
Wrist extension	30 (7.3)	28 (14.9)	–	54.9 (13.4)
Radial deviation	18 (8.2)	10 (6)	–	17.2 (6.5)
Ulnar deviation	11 (9.4)	16 (3.2)	–	38.9 (7.6)
Key pinch strength (kg)	4 (3.5)	–	3.6 (2.7–5.0)	5 (1.4)
Grip strength (kg)	9 (8.9)	21 (11.5)	20 (12–24)	22.5 (5.8)
Age (y)	73 (4.3)	47.8 (15.4)	57 (44–75)	

Abbreviations: 4CF, four-corner fusion; LRTI, ligament reconstruction tendon interposition; RCE, radial column excision; SD, standard deviation.

Table 3 PRWE scores post-RCE and 4CF

	Pain (/50)	Function specific (/60)	Function usual (/40)	Function (/50)	Total (/100)	DASH
1 ^a	27	42	19	30.5	57.5	47.4
2 ^b	45	52.5	35	44	89	72.9
3	10.5	0	0	0	10.5	9.3
4	20	11	9.5	10.25	30.25	25.4
5	18	5	0	2.5	20.5	17.4
6	15	11	11	11	26	21.9
Mean (SD)	22.6 (12.3)	20.3 (21.6)	12.4 (13.2)	16.4 (17.3)	39.0 (29.1)	32.4 (23.6)

Abbreviations: 4CF, four-corner fusion; DASH, Disabilities of the Arm, Shoulder and Hand; PRWE, patient-rated wrist evaluation; RCE, radial column excision; SD, standard deviation.

Note: DASH score calculated as $DASH = 0.81 + 0.81 \times PRWE$.²¹

^{a,b}Two-stage procedure of trapeziectomy and subsequent trapeziectomy and 4CF.

Table 4 Radiographic outcomes following RCE. Pre- and postoperative measurements

Parameter	Mean	SD	Range
Modified carpal height ratio	1.5	0.3	1.3–2
Preoperative scapholunate angle (degrees)	59.9	32.2	19.8–87
Preoperative radiolunate angle (degrees)	18.9	10.7	7.3–33
Postoperative radiolunate angle (degrees)	6.4	3.3	1.2–9.3

Abbreviations: RCE, radial column excision; SD, standard deviation.

Fig. 5 Wrist range of motion (ROM) comparing radial column excision (RCE) with four-corner fusion (4CF) and normative controls. Error bars represent 1 standard deviation.

wrist as controls as two of the patients had surgery to both the wrists. We were unable to measure the degree of thumb metacarpal subluxation due to absence of the scaphoid and trapezium and fusion of the midcarpal joint.

In this uncommon subset of patients with basal thumb arthritis and wrist arthritis limited to either the scaphoid fossa or lunocapitate joint, RCE with 4CF can be performed as a single-stage and acceptable clinical outcomes with no failures at a minimum of 34 months follow-up.

Fig. 6 Grip and key pinch strength post-RCE compared with trapeziectomy and ligament reconstruction tendon interposition (LRTI) and normative controls. Error bars represent 1 standard deviation.

Note

This study was performed at Victorian Hand Surgery Associates. This study has been granted ethics approval by the St. Vincent's Hospital Melbourne Human Research Ethics Committee, HREC No. HREC/16/SVHM/113.

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None.

Conflict of Interest
None.

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