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RESEARCH ARTICLE

Arthroscopic three-corner or lunocapitate arthrodesis: technical tips and early outcomes

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ABSTRACT

The purpose of the study is to present a technical approach for arthroscopic three-corner or lunocapitate arthrodesis with mini-open scaphoid excision and to report about the early clinical and functional results. The median surgery time was 112 min with shorter times achieved once mastering the technique. Radiological and clinical union was observed in 11 out of 12 patients in a median time of five months. For final assessments nine patients were included with a median follow-up of 15 months. Wrist extension and flexion after surgery decreased to 58 and 62% of preoperative measurements and represented 37 and 42% of the unaffected side. Grip strength also decreased to 80% of the preoperative value and 57% of the unaffected side. All patients reported significant pain relief and functional improvement. Arthroscopic three-corner or lunocapitate arthrodesis was a safe, reliable and minimally invasive technique for treating wrist osteoarthritis, while it was technically demanding and time-consuming during learning curve.

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Three-corner arthrodesis; lunocapitate arthrodesis; partial wrist arthrodesis; wrist fusion; wrist arthroscopy

Introduction

Wrist degenerative changes are often related to the biomechanical disequilibrium following scaphoid nonunion advanced collapse (SNAC), scapholunate advanced collapse (SLAC) or scaphoid chondrocalcinosis advanced collapse (SCAC). The most appropriate surgical treatment for wrist osteoarthritis stage 2 [1,2] is still debated, as partial wrist arthrodesis commonly results in better strength, while proximal row carpectomy (PRC) often produces better wrist arc of motion and fewer complications [3,4]. However, in stage 3 wrist osteoarthritis, motion preserving partial wrist arthrodesis such as lunocapitate arthrodesis (LCA) [5–8], three-corner arthrodesis (3CA) or four-corner arthrodesis (4CA) seem to be widely accepted as treatment of choice [7–9]. Recent studies suggest a superiority of 3CA and LCA over 4CA in terms of final wrist arc of motion and patient reported outcome measures, while union rate and complications appear comparable for both techniques [9–12]. At the same time, the arthroscopic approach has steadily improved and gained ground [13–15]. For a long time, the main concern was the demanding technique and the union rate. Indeed, the experience of Baur *et al* [16] with a big series of arthroscopic 4CA, 3CA and LCA underlines the steep learning curve. Nevertheless, better final function and range of motion (ROM) are reported for the arthroscopic technique compared to the open approach [16]. Moreover, the superiority of arthroscopic partial wrist arthrodesis as regards the final wrist ROM has been recently further demonstrated in a retrospective case control study [17]. Based on these findings, we opted for arthroscopic 3CA and LCA with open scaphoid excision for treatment of SNAC, SLAC and SCAC stages 2 and 3 or stable inflammatory wrist osteoarthritis. In decision making for 3CA or LCA, the type of lunate had a key role. In patients with a type 2 lunate [18], both the lunocapitate (LC) und lunohamate (LH) joints were fused. Otherwise, LCA was preferred for its simplicity and lower need of bone graft. In both 3CA and LCA we preserved the triquetrum after having excluded concomitant pisotriquetral arthritis, disruption or incompetence of the lunotriquetral (LT) ligaments and ulnocarpal impingement. In our opinion, in absence of these findings, preservation of triquetrum contributes to rotational stability and may reduce radiolunate contact pressure, as previously suggested in a biomechanical cadaver study [19].

The aim of this study is to present our technical tips for arthroscopic 3CA and LCA arthrodesis, report about our early outcomes and compare them with the current literature.

Materials AND methods

Patients

After obtaining approval from institutional board (Cantonal Ethics Committee Zurich, ID 2017-02003) we retrospectively identified patients operated with arthroscopic 3CA or LCA from December 2015 to December 2017. Twelve patients (nine women) with median age 50 years old (33–70), five of them manual laborers and six of them with prior wrist surgeries, were identified and invited for clinical and functional assessment. Nine of them provided written consent for the clinical follow-up, while all three remaining patients gave verbal consent for further use of already collected data and were included only for retrospective union rate and time to union assessment. Radiological preoperative assessment with computed tomography scans (CT) had demonstrated SLAC/SNAC/SCAC arthritis in ten and stable inflammatory arthritis in two patients, all with preserved radiolunate joint. Type 2 lunate was seen in seven patients, these were offered 3CA and

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the remainder were offered LCA. The dominant hand was operated in eight patients. The median surgery time was 112 min (95–189).

Technique

Surgery is carried out under regional anesthesia and tourniquet until final screw insertion. A standard dry arthroscopic technique as described by del Pinal [14,20] is performed. We initiate cartilage and subchondral bone denudation with an oval-burr for small joints (AR-7300OBT, Arthrex, Belp-Bern Switzerland) and complete the procedure by smoothly flattening the surfaces with a power rasp (PoweRasp™ 3.5 mm x 6.5 mm, Arthrex, Belp-Bern, Switzerland) (Figure 1). In type 2 lunate wrists, we decorticate and flatten the hamate tip to facilitate lunate reduction and reduce the risk for pseudarthrosis or impingement. Afterwards, scaphoid is removed piece-meal through a 2 cm volar incision (10 min procedure) and used as sole source of bone graft (Figure 2). Lunate reduction is performed through flexion and radial translation of the carpus and temporary pinning of the RL joint. Thereafter, we begin with the lunocapitate joint fixation by retrogradely inserting a 1.1 mm guidewire through a 2 mm incision at the basis of 3rd metacarpal parallel to the coronal plane of the wrist to prevent from entering the carpal tunnel. A sharp drill guide (A-2007, Aptus Medartis, Basel, Switzerland) (Figure 3) allows a more accurate and atraumatic insertion. In 3CA, a second guidewire is inserted at the basis of the 5th metacarpal for the LH joint (Figure 4) aiming to a more dorsal position in the lunate compared to the first wire. For graft insertion, we use a screw driver sleeve (Figure 5) and first place the bone graft at the arthrodesis site before advancing the guidewires through it. After graft placement, we remove the hand from traction, advance the wires and check under fluoroscopy the arthrodesis position. Followingly, we slightly withdraw one of the wires without completely removing it, and insert the first compression screw (SpeedTip CCS, 3.0 headless cannulated compression screws, Aptus Medartis, Basel, Switzerland). Followingly, we advance again the second guidewire (Figure 6) and insert the second compression screw. We have observed that if we leave both guidewires in place while inserting the screws, their convergence will prevent compression. Arthrodesis is now completed with removal of guidewires. Under fluoroscopy the wrist is moved through the residual range of motion to check for potential radiocarpal impingement. If this is observed, then a resection of radial styloid is performed arthroscopically. Skin incisions are closed with intracutaneous sutures (Figure 7).

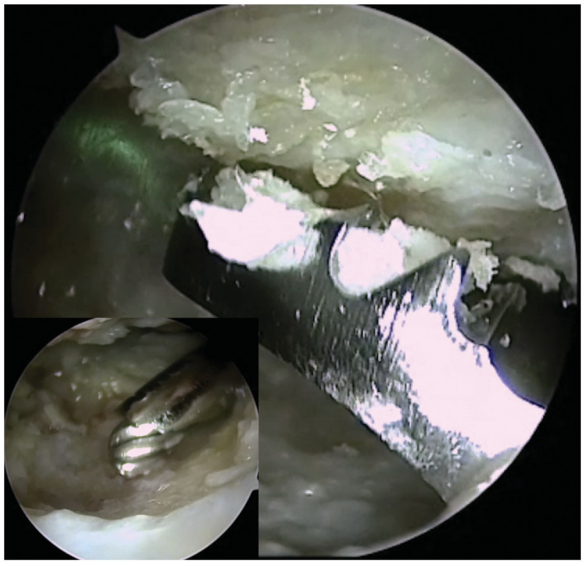

Figure 1. The oval-burr for small joints (on the left) and the power rasp for cartilage removal and subchondral bone denudation (on the right).

Figure 2. The scaphoid is excised through a mini-open palmar approach and serves as the unique source of bone graft.

Rehabilitation

The wrist is immobilized in a non-removable cast for four weeks followed by isometric wrist mobilization and use of protective cast for further four weeks. Full weight bearing is allowed at earliest eight weeks after surgery.

Clinical follow-up and radiological union assessment

Active wrist range of motion (ROM), grip strength measurement with Jamar dynamometer (position 2), pain evaluation with visual analogue scale (VAS) during active motion, Disability of the Arm, Shoulder and Hand score (DASH) and Patient-rated Wrist Evaluation (PRWE) for both pain and function [21] were recorded preoperatively and at final follow-up by an experienced occupational therapist. First radiological union assessment was

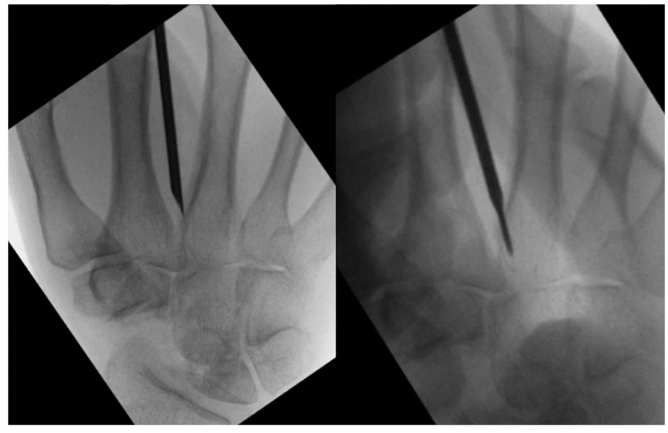

Figure 3. Placement of a sharp drill guide at the basis of 3rd metacarpal through a small skin incision for precise and stable guidewire insertion.

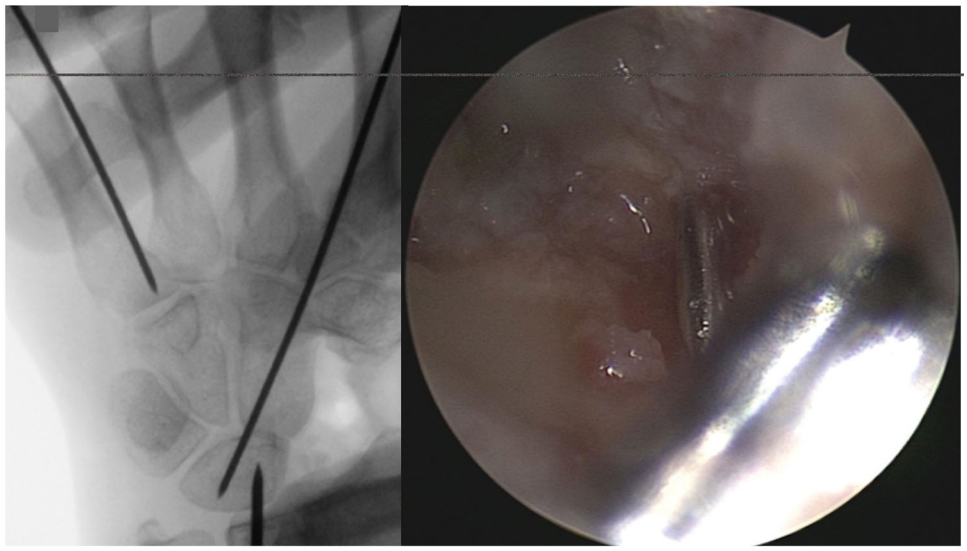

Figure 4. Retrograde insertion of the second guidewire for lunohamate fixation in 3CA.

Figure 5. Arthroscopically assisted insertion of bone graft from the excised scaphoid.

performed with computed tomography scan (CT scan) at 6 weeks postoperatively and thereafter every four to six weeks with X-rays or, if needed, with CT scan, up to total union. Radiographic evidence of osseous union was defined as the presence of bridging bone trabeculae and was evaluated independently by two of the authors. Hardware loosening, migration or radiolucency were considered as indirect signs of nonunion. Complications, need for reoperation and time to return to work were also recorded.

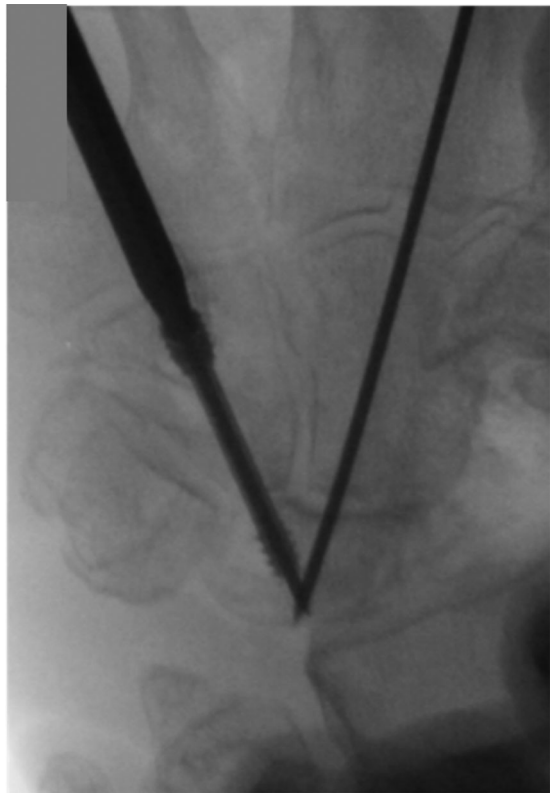

Figure 6. In cases of 3CA, following the insertion of the first compression screw the second guidewire is again advanced at the arthrodesis site.

Statistical analysis

Only descriptive statistics were performed due to the small sample size. Results are presented as medians (range). There is no control group in this study.

Results

Total union was achieved in 11 out 12 patients in a median time of 5 months (3–12). In Figure 8 is presented the radiological outcome six months after LCA for SLAC stage 2 due to chronic underdiagnosed traumatic rupture of the scapholunate ligament at a 57-year old woman. In Figure 9 is shown the radiological outcome one year after 3CA at a 68-year old woman with SLAC stage 3 due to chronic rupture of the scapholunate ligament related to crystalline arthropathy. Nonunion and lunohamate impingement complicated one LCA patient. During revision surgery, a progression of osteoarthritis at the proximal lunate was detected and a total wrist fusion was applied. This patient was excluded from wrist extension and flexion outcome measurement. Loosening of hardware with proximal migration of one screw occurred in one patient with 3CA and diffuse scleroderma. Following to screw

removal two months after index surgery further healing was uneventful (Figure 10). Lastly, carpal tunnel syndrome was presented shortly after another 3CA.

The median follow-up time for clinical scores and outcomes was 15 months (3–27). In regards to wrist ROM, we observed a median 41% (20–64%) decrease of extension and 38% (0–80%) decrease of flexion postoperatively. When compared to contralateral side, extension and flexion after surgery were 37% (26–50%) and 42% (33–86%) respectively. Postoperative radial and ulnar inclination were 66% (50–100%) and 50% (30–80%) of contralateral side, while pronation and supination remained practically unchanged. Grip strength was 80% (66–114%) of preoperative value, while preoperative and postoperative grip strength corresponded to 66% (50–83%) and 57% (34–75%) of contralateral side. All patients reported pain relief. Median pain (VAS) during active motion was 7 (3–9) preoperatively and 1 (0–4) after surgery. A median decrease of 29% (3–55%) in DASH score and 19% (−6–46%) decrease in PRWE score was also observed. Detailed results are shown in Table 1 and Table 2.

All nine patients returned to their previous works in a median time of 3.5 months (1.5–7).

Figure 7. Closure of skin incisions with intracutaneous resorbable sutures.

Discussion

Limitations of our study relate to the low number of patients (only nine included for final follow-up), the short follow-up time of 15 months (3–27) and its retrospective nature. Another limitation preventing us from drawing quantitative conclusions is the lack of a comparative control group.

In our case series of arthroscopic three-corner arthrodesis and lunocapitate arthrodesis for SNAC, SLAC and SCAC wrists stage 2 and 3 and inflammatory midcarpal arthritis, we demonstrated a 92% union rate (11 out of 12 wrists) achieved in a median time of 5 months. The union rate was comparable with the one reported by Dutly-Guinand and von Schroeder [7], who presented a successful union in 12 out of 13 patients with open 3CA with scaphoidectomy and triquetrum preservation through a palmar approach. Our fusion incidence was also similar or slightly better to other studies of open 3CA or LCA and triquetrum excision or bicolumnar arthrodesis [6,9,22].

With respect to surgery time, we recorded a median duration of 112 min, which is similar to the one reported by del Pinal after familiarization with the technique [14]. In another subseries of seven arthroscopic LCA and one 3CA with open scaphoid excision (out of a larger cohort of arthroscopic partial wrist arthrodesis), mean operation time was found to be around three hours, which indicates more than one tourniquet time [16]. Authors suggest that, after familiarization with the technique and especially with its tricky part of guidewires placement, surgery can be safely accomplished in one tourniquet time. Moreover, open scaphoid excision does permit to gain valuable time, while additional morbidity through the small palmar incision remains, in our opinion, negligible.

Necessity of triquetrum excision still remains an open discussion. In the majority of previous studies with open 3CA or LCA, the triquetrum had been routinely removed [6,8–11,22]. According to supporters of triquetrum excision, theoretical advantages are better union rate, prevention from ulnocarpal

Figure 8. A 57-year old woman was diagnosed with SLAC stage 2 following a chronic traumatic scapholunate rupture. X-rays from left to right: Anteroposterior and profile views preoperatively and 6-months after LCA with two headless compression screws.

Figure 9. A 68-year old woman with SLAC stage 3 due to crystalline arthropathy. X rays from left to right: Anteroposterior and profile views preoperatively and 12-months after 3CA with two headless compression screws.

Figure 10. A 70-year old woman with polyarthritis and systemic scleroderma presented a clinically decompensated midcarpal arthritis and triquetrum fracture after a fall on her right hand. X rays from left to right: Anteroposterior and profile views preoperatively and 12-months after 3CA. The headless compression screw for the lunocapitate joint had to be removed 2 months after surgery due to loosening. Screw fixation of the triquetrum fracture.

Table 1. Preoperative and postoperative patient reported outcomes.

Pat	FU (mo)	DASH preop	DASH postop	PRWE preop	PRWE postop	VAS preop	VAS postop
1/LCA	8	29	28	33	30	6	1
2/LCA	3	50	45	47	37	8	2
3/LCA	15	38	17	57	30.5	5	0
4/LCA	16	43	27	70.5	59	6	4
5/3CA	25	39	25	NA	20	9	0
6/3CA	12	33	23	40	27	3	1
7/3CA	27	71	68	49	32	8	3
8/3CA	11	NA	27	29.5	31.5	7	2
9/3CA	16	63	45	70	63	8	1
Median (range)	15 (3–27)	41 (29–71)	27 (17–68)	48 (29.5–70.5)	31.5 (20–63)	7 (3–9)	1 (0–4)

Values are represented as medians (range).
Pat: patient, FU: follow-up, mo: months, VAS: visual analogue scale for pain evaluation. DASH: Disability of the Arm, Shoulder and Hand score. PRWE: Patient-rated Wrist Evaluation (sum of pain and function subscales). Preop: preoperative values, postop: postoperative values, NA: not applied or missing data.

impingement and pisotriquetral arthritis and easier lunate reduction. After having excluded pisotriquetral arthritis and incompetence of LT ligament, we opted for triquetrum preservation and did not experience any unfavorable impact on union rate.

As to postoperative wrist arc of motion, median extension and flexion were 58% (36–80%) and 62% (20–100%) of preoperative measurements. These are comparable with the results of Calandruccio *et al* after open LCA with scaphoid and triquetrum excision in 14 patients [6]. Shim *et al* recently reported that arthroscopic versus open 4CA did not show significant differences in clinical outcomes and bone union rates [17]. In the current study we have not found better wrist extension/flexion compared to open 3CA and LCA. Similarly, our median postoperative radial and ulnar inclination were lower compared to other studies with arthroscopic 4CA [17], open 3CA or LCA with triquetrum excision [9,11], Interestingly, our finding is confirmed by *in vivo* three-dimensional motion analysis of the wrist in a subgroup of our study patients [23]. Dargai *et al* reported a significant

Table 2. Clinical outcomes.

Pat/ Surg	Preop wrist ext	Postop wrist ext	Contra wrist ext	Preop wrist fle	Postop wrist fle	Contra wrist fle	Rad incl postop	Rad incl contra	Uln incl postop	Uln incl contra	Pron postop	Pron contra	Supin postop	Supin contra	Grip preop (kg)	Grip postop (kg)	Grip contra (kg)
1/ LCA	55	20	75	60	30	80	15	25	15	40	90	80	90	100	20	17	24
2/ LCA	50	25	65	60	60	70	20	25	30	45	90	90	90	90	18	12	25
3/ LCA	30	20	75	65	40	85	25	25	20	40	80	80	90	85	36	38	54
4/ LCA	NA	NA	NA	NA	NA	NA	20	30	15	50	90	95	75	75	33	24	46
5/ 3CA	50	30	60	40	25	65	10	20	20	25	80	80	85	85	16	18	24
6/ 3CA	50	40	80	45	45	60	20	30	30	40	90	90	90	90	12	8	23
7/ 3CA	40	30	NA	50	10	NA	20	NA	5	NA	90	NA	90	NA	7	8	14
8/ 3CA	35	20	60	30	30	90	15	30	20	50	100	110	60	70	30	24	42
9/ 3CA	65	30	80	60	30	70	30	35	15	30	80	70	95	90	14	10	26
Median (range)	50 (30–65)	27.5 (20–40)	75 (60–80)	55 (30–65)	30 (10–60)	70 (60–90)	20 (10–30)	27.5 (20–35)	20 (5–30)	40 (25–50)	90 (80–100)	85 (70–110)	90 (60–95)	87.5 (70–100)	18 (7–36)	17 (8–38)	25 (14–54)

Pat: patient, surg: surgery, mo: months, NA: not applied, ext: extension, fle: flexion, preop: preoperative, postop: postoperative, contra: contralateral, rad: radial, uln: ulnar, pron: pronation, supin: supination. Patient 7/ 3CA had received in the past a radioscapholunate arthrodesis on the contralateral wrist and was, therefore, excluded from comparison of both sides.

improvement of the wrist range of motion after open LCA and scaphoid and triquetrum excision in a 10 years follow-up [11]. Opposingly, with the current study we report an overall decrease of wrist ROM.

In regards to postoperative grip strength, the majority of other studies demonstrated an increase of grip strength after midcarpal arthrodesis (70–80% of unaffected side), regardless of whether surgery was open or arthroscopic [6,8–11,17]. In our case series, grip strength was 57% of unaffected side and 80% of preoperative value. We consider that our decreased grip strength is, on one hand, explained by our much shorter follow-up period and, on the other hand, by the fact that some patients suffered from inflammatory disease (scleroderma, CPPD, …). Our study, however, does not represent a direct comparison between open and arthroscopic techniques or among 4CA, 3CA and LCA, so no sure conclusion can be made here.

To conclude, arthroscopic LCA or 3CA is an alternative to open procedures or 4CA for SNAC, SLAC and SCAC wrists at stage 2 and 3 in terms of union rate. It is technically demanding and time-consuming during learning curve. We found no superiority in terms of clinical outcomes and scores compared to the other methods. Limited tissue exposure, less damage to capsular structures including dorsal carpal ligaments [13], smaller incisions and better aesthetic results are potential benefits over open approach. Further comparative studies with longer follow-up and larger cohorts are needed to assess the effect of triquetrum preservation and to quantitatively compare outcome measurements between open and arthroscopic 3CA and LCA.

Disclosure statement

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