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Reconstruction of an early stage SLAC wrist with the 3-LT procedure: A controversial reappraisal.

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Short Running Head: 3-LT in early stages of SLAC wrists

ABSTRACT

Objective: We hypothesized that the three-ligament tenodesis (3-LT) procedure is still sufficient - even in scapholunate advanced collapse (SLAC) cases - to reduce pain and improve wrist function. We compared patient-reported outcomes of scapholunate interosseus ligament (SLIL) injury patients with SLAC to SLIL injury patients treated with 3-LT, and then to patients who received proximal row carpectomy (PRC), as a control group.

Method: We included all patients with a traumatic SLIL injury and associated SLAC components treated with 3-LT and completed Patient Reported Wrist Evaluation (PRWE) questionnaires preoperative and at 12 months follow-up. First, we compared matched patients with SLIL injury and SLIL injury with SLAC, stage 1-3, who received 3-LT. Second, we compared patients who received 3-LT, with patients who underwent PRC, while having SLAC stage 2-3.

Results: We compared 51 patients with SLAC to 95 with SLIL injury who had a 3-LT procedure, and 10 3-LT patients were compared to 18 patients undergoing PRC, given SLAC 2-3. In both analyses, the PRWE scores had significantly improved in all groups, however no significant differences in PRWE were found between 3-LT in SLIL injury and SLIL injury with SLAC, 6.9 points (95% CI [-14.92; 1.22], p = 0.096) and between 3-LT and PRC, given SLAC stage 2-3, 15.1 points (not enough power).

Conclusion: There is no difference in PRWE between matched SLIL injury patients with or without degenerative changes treated with a 3-LT. Therefore, the 3-LT procedure seems to be a viable treatment option for patients with early-stage SLAC wrist.

Level of evidence: Therapeutic III

Keywords: Three-ligament tenodesis; Scapholunate ligament; Scapholunate advanced collapse; Proximal row carpectomy; Patient-Reported Outcome Measures.

Introduction

The scapholunate interosseous ligament (SLIL) is a key intercalating stabilizer of the wrist, ensuring normal motion of carpal bones [1]. Traumatic injuries to the SLIL are mainly known for producing instability of the intercarpal joints, causing pain and dysfunction [2]. Attenuation of the SL ligament will cause the scaphoid to abnormally deviate in a flexed position and the lunate pathologically in extension, which results in a pattern of dorsal intercalated segment instability (DISI deformity) [3]. This condition leads to altered wrist kinematics and joint loading, causing damage to surrounding structures in the wrist, ultimately leading to degenerative osteoarthritis [2,4,5].

The most common pattern of posttraumatic wrist arthritis involves the radioscaphoid and capitolunate joints, known as Scapho-Lunate Advanced Collapse (SLAC) [6]. Watson and Ballet introduced a classification system for SLAC wrist and identified different radiologic stages of degenerative osteoarthritis, which predictable progress. The degenerative changes invariably progress from articulation between the distal scaphoid and radial styloid (stage 1) to the scaphoid fossa (stage 2) and finally involve the capitolunate joint (stage 3) [6,7].

The 3-LT procedure is a commonly used reconstructive technique to restore the normal alignment of carpal bones and possibly thereby prevent the occurrence of osteoarthritis; however, this is contra-indicated when SLAC is present in the wrist. This is a core principle in hand surgery: when there is osteoarthritis, ligament reconstruction is not considered a treatment option [8]. The accepted surgical treatments for a SLAC wrist are dependent on the stage and level of osteoarthritis. Multiple operative procedures are feasible in each SLAC stage and local preferences exist on this matter but generally, in literature, it is recommended to perform a radial styloidectomy in SLAC stage 1. In SLAC stage 2 and up, salvage procedures such as proximal row carpectomy (PRC), midcarpal, or total wrist fusion are usually performed [3,9]. However, the PRC is the preferred and most commonly performed

surgical treatment for SLIL injury with SLAC [10]. In general, all these surgical options are salvage treatments and do not reconstruct the normal carpal anatomy.

However, it can be hypothesized that damage to the articular surface in a SLAC wrist may be limited and may not progress to the entire joint surface when carpal kinematics are restored. The 3-LT procedure relieves pressure on the osteoarthritic parts, reducing pain and improving wrist function. This would restore normal articulation and possibly thereby prevent loss of congruence, and postpone salvage procedures. Therefore, this study aims to examine the patient-reported outcomes of SLIL injury patients with SLAC, type 1 to 3, treated with 3-LT with one-year follow-up. We compared them to the outcome of SLIL injury patients treated with 3-LT. Because PRC is a preferred procedure in SLIL injury with SLAC, we deemed it necessary to also compare 3-LT patients to patients that received a PRC, both when treated for SLAC wrists stage 2 or 3.

Methods

Study cohort

This observational cohort study looked at a subset of data from a database, which was also used for previously described studies [11,12] at Xpert Clinics in the Netherlands. Xpert Clinics is a consortium comprising 22 outpatient clinics for hand surgery and therapy. Patients [13] treated with 3-LT between December 2011 and December 2019 and who completed the Patient Rated Wrist Evaluation (PRWE) questionnaire at intake, were included. The study was performed with the approval of the local Medical Ethical Committee (Rotterdam, NL/sl/MEC-2018-1088). All patients had given prior informed consent to the anonymous use of their data. Patients with a traumatic SL-lesion were eligible for inclusion. Electronic patient files were assessed on medical history and medical imaging (X-ray, CT, MRI, and/or arthroscopic theater) reports were evaluated to identify the traumatic cause. A traumatic injury was defined as a complete rupture (Geissler 4) of the SL ligament or a partial rupture (Geissler 2 or 3)

caused by a clear traumatic event [14,15]. Patients were excluded if the 3-LT procedure was a reoperation, when the procedure was combined with another surgical treatment intervention, such as a styloidectomy or ulnar shortening osteotomy, or when another surgical procedure was performed within 8 weeks before or after the 3-LT operation. Patients with Scaphoid Nonunion Advanced Collapse (SNAC), Perilunate wrist injuries, or Kienbock were also excluded from the analyses. Other exclusion criteria were midcarpal instability or laxity as a reason for the 3-LT procedure, and the presence of incomplete medical records. Wrist arthroscopies were considered a diagnostic procedure and therefore when arthroscopies were combined with or were performed within 8 weeks of the open 3-LT procedure, patients were not excluded. Fully arthroscopic assisted 3-LT procedures were excluded. As a control group, we included patients who received PRC for the indication SLAC stage 2 or 3.

Surgical technique

3-LT

An experienced anesthetist applied regional block anesthesia. Our 3-LT technique is based on what was previously described by Garcia-Elias et al [8]. Firstly, the SL ligament is approached dorsally through the third and fourth extensor compartments of the wrist. Subsequently, a volar incision is made to expose the tubercle of the scaphoid and the Flexor Carpi Radialis (FCR) tendon. A K-wire is passed centrally through the scaphoid. A cannulated 2.7mm drill bit is then used to drill a hole through the scaphoid in a longitudinal direction. Thereafter, a strip of the FCR tendon is passed through the scaphoid from volar to dorsal. Once the DISI deformity is restored, a bone anchor (MITEK; Raynham, Massachusetts, USA; JuggerKnot Soft Anchor; Zimmer Biomet, Warsaw, Indiana, USA) [16] is used to fixate the graft to the lunate. The JuggerKnot Soft Anchor is an all-suture device and lacks polyether ether ketone or other composite material, but uses a coreless sleeve and suture construct [17]. The FCR strip is then passed through the radiotriquetral ligament, after which the FCR strip is sutured to

itself. K-wires were not used for the temporary fixation of carpal bones. A posterior interosseous nerve (PIN) neurectomy was part of the standard procedure. Postoperatively, patients were immobilized for 3 to 5 days, after which a personalized orthosis was given for up to 6 weeks during the day and up to 12 weeks at night, and they were offered a 3-month extensive hand rehabilitation program.

PRC

The procedure is generally performed under regional block anesthesia. A dorsal approach via the fourth extensor compartment is used. A radially based flap / Berger flap is created to provide an adequate view of the proximal and distal carpal rows. Next, the scapholunate and lunotriquetral interosseous ligaments are severed, allowing the complete removal of the scaphoid, lunate, and triquetrum bones. Radial styloidectomy was not routinely performed, this was left to the discretion of the surgeons. A PIN resection was part of the standard procedure. The wrist capsule and skin were closed and a volar patch of Paris splint was applied. Postoperatively, patients were immobilized for 3 to 5 days, after which a personalized orthosis was given for up to 6 weeks during the day and up to 12 weeks at night, and they were offered a 3-month extensive hand rehabilitation program.

Data sources

The patient-reported outcomes were acquired from routine questionnaire administration in our practices using a process of electronic data collection previously described [18]. Participants were asked to answer electronically based questionnaires regarding specific risk factors and patient-related outcome measures at baseline, 3 months, and 12 months postoperatively. Electronic patient records of 3-LT patients were searched for the presence of SLAC preoperatively. Two independent plastic surgeons evaluated the medical imaging and arthroscopic records of patients in whom SLAC was suspected or mentioned in their electronic records and subsequently classified the patient's degenerative osteoarthritis into the

corresponding stages. Complications and any additional surgical procedures for osteoarthritis in the follow-up of 3-LT were also recorded (e.g., PRC, anterior and posterior interosseous neurectomy, or styloidectomy). If a PIN structure, or neuroma was identified, re-resection was performed.

Outcome measures

The primary endpoint of this study was the change in PRWE total score from baseline to 12 months postoperative. The PRWE is a questionnaire that consists of 15 questions related to patients' pain and the functionality of the wrist. Participants score these questions on a scale ranging from 0 (no pain or dysfunction) to 10 (severe pain and dysfunction) [19]. Pain and function scores together make up the total score. High PRWE scores indicate more pain or dysfunction. Change in PRWE was calculated by subtracting the total score at intake from the total score at 12 months postoperative.

Secondary endpoints were complications and conversion rate to additional surgical treatment of osteoarthritis in the wrist in the follow-up of 3-LT. Complications were scored following the International Consortium for Health Outcome Measurement (ICHOM) Complications in Hand and Wrist conditions (ICHAW) classification, which is modified from the Clavien–Dindo classification for general surgery [20]. This tool classifies complications within 12 months after surgery into different grades based on the treatment it requires. When a complication is not sufficiently relieved with minimally invasive treatment and more invasive treatment was given, only the complication with the highest grade is reported. For grade 3 complications (additional surgery) a longer follow-up was established. Patients were followed up to 9 years, with a median of 4.7 years (IQR 2.7 – 6.7 years).

Power

We performed an a priori power calculation for our primary analysis comparing SLIL injury patients and SLIL injury patients with SLAC components, both treated with a 3-LT, at one

single time point. When using a 2:1 allocation rate and an α of 0.05 and a power of 0.8 we would have been able to detect an effect size of 0.5 or greater between the groups of 48 and 96. This would only have been an effect size of 0.95 or greater for the comparison with the PRC group. Any analysis with fewer participants would be underpowered and therefore not formally tested.

Bias

Confounding was likely to be present which risks the genuine association between the presence of SLAC and PRWE outcomes after 3-LT to be distorted. Propensity score matching (PSM) was applied to have comparable groups. The baseline characteristics used to match participants were age, gender, duration of symptoms, dominant hand, profession (heavy/moderate/light/no), pain, and function score at intake. In the second analysis, participants were also matched on the SLAC stage. All variables were weighted equally in the calculation. We used a 1:2 matching ratio and the nearest neighbor technique from the MatchIt package in R [21]. If no matches were found, the associated data was omitted from the analyses.

Statistical analyses

In this study, we carried out two analyses. First, between SLIL injury patients and SLIL injury patients with SLAC stage 1-3, both treated with a 3-LT. Second, between patients who received a 3-LT and patients who underwent a PRC, while having SLAC stage 2-3. We performed separate PSM for each analysis, see Tables 1 and 2.

Paired t-tests were performed to determine the statistical significance of the change in PRWE within a group between two-time points (12 months postoperative and preoperative). Unpaired t-tests were performed to calculate the significance of the change in PRWE between the groups in the analyses.

Kaplan Meyer (KM) method was used to assess the conversion rate to additional surgical treatment of osteoarthritis per SLAC classification (stage 0-3) after 3-LT was performed. Patients were censored from the analysis when a competing event took place after 3-LT, which could for itself have been the provoking factor for additional treatment of dealing with complaints of osteoarthritis. In addition, patients whose follow-up ended early due to unforeseen reasons, like travel abroad, were censored by the time of last available data. The statistical level of significance was defined as a p-value of less than 0.05. All analyses were performed using R version 3.6.0.

Results

3-LT in SLIL injury vs 3-LT in SLIL injury with SLAC

In total, 311 of 480 patients who were treated with 3-LT during the study period were eligible for inclusion. Of these 311 participants, 258 patients did not show any signs of SLAC, and 53 patients were diagnosed with SLAC, see Figure 1. Table 1 shows the differences in baseline characteristics in the pre-and post-match comparison. After matching, the PRWE scores at one-year follow-up had significantly improved in both groups, SLIL injury and SLIL injury with SLAC, respectively 30 points ($p < 0.05$) vs 23 points ($p < 0.05$). Furthermore, no significant difference in PRWE between the matched groups was found after 12 months follow-up, 6.9 points (95% CI [-14.92; 1.22], $p = 0.096$) (Figure 2).

3-LT with SLAC stage 2 or 3 vs PRC with SLAC stage 2 or 3

In the second analysis, 10 of 14 patients who were treated with a 3-LT were compared with 18 of 127 patients who underwent a PRC, while having SLAC stage 2 or 3, see Figure 1. Table 2 presents the differences in characteristics between both groups before and after the matching procedure. After PSM at 12 months follow-up, the PRWE scores had significantly improved in both groups, 3-LT and PRC in SLAC 2 or 3, respectively 21.9 points ($p < 0.05$) and 37.0 points ($p < 0.05$) (Figure 3). We did not formally test the difference between these

groups, since these groups' sizes do not meet the required power.

Complications

Table 3 shows the complications of all patients with a traumatic SLIL injury treated with a 3-LT for all stages of SLAC. According to the ICHAW system, 15% of patients had grade 1 complications, 12% grade 2 complications, and 12% grade 3 complications (see Table 3). The percentage of complications varies between groups but grade 1 and 2 complications do not seem to be more prevalent in a specific group.

Conversion rate to additional surgery (Grade 3 complications)

In total, 19 of 480 patients converted to an additional surgical osteoarthritis treatment after the 3-LT procedure during the median follow-up of 4.5 (IQR 2.7 – 6.7 years), see Figure 1. Of these 19 patients, 13 participants received a PRC in their follow-up of 3-LT. In 4 patients an additional neurectomy of the posterior and anterior interosseous nerve was conducted. Additionally, one patient received a radial styloidectomy to address osteoarthritis. Lastly, one patient received a scaphoid excision after being treated with a 3-LT.

SLAC components in the wrist were identified preoperatively in 10 of these 19 patients, see Figure 1. At maximum follow-up of 9 years, 14.7% of all patients identified with SLAC (n=80) converted to an additional surgical osteoarthritis treatment after the 3-LT procedure, however, patients with higher SLAC stages converted more frequently. The conversion rate was 2.3% in SLAC 0 (n=400), 11.2% in SLAC 1 (n=62), 18.2% in SLAC 2 (n=13), and 50.0% in SLAC 3 (n=5) (see Supplementary S1).

Discussion

This study aimed to investigate whether the 3-LT procedure is a viable treatment for traumatic SLIL injury patients with SLAC-stage wrists. Therefore, we examined the change in PRWE from intake to 12 months postoperatively and compared it with SLIL injury patients treated with a 3-LT and patients who received a PRC, while using propensity score matching. All

groups had significantly improved PRWE scores at 12 months postoperative. No significant differences were found in PRWE total score in the first year postoperatively between the matched 3-LT patients with SLIL injury and SLIL injury with SLAC wrists. Our findings support the hypothesis that the 3-LT can be valuable in SLAC patients, particularly in grades 1 and 2. However, due to the limitations of observational research, we are cautious to draw any definitive conclusions that can only be obtained in a randomized controlled trial.

The improvement in our cohort is comparable to previously reported PROMs after 3-LT. A previous study showed a significant improvement in PRWE scores between 0 and 12 months postoperative with continuous improvement in patients who underwent 3-LT for SLIL injury. A PRWE total score improvement of 31 points was found [22], which is similar to the 30 points improvement of the matched 3-LT patients with SLIL injury in our study. This indicates that the matched cohort is a good representation of the patients treated with 3-LT due to SLIL injury. Studies by Atlani et al.[23] and Pauchard et al.[24] found an improvement in PRWE of around 22 points and QuickDASH of around 18 points in their follow-up of patients treated with 3-LT, which seems to be slightly worse than the patients identified with SLAC stage 1-3 in our present study.

Currently, the PRC or midcarpal fusion is the gold standard for the treatment of SLAC stage 2/3 wrists [3,9]. The choice between a PRC and a four-corner arthrodesis depends on the preference of the surgeon, as the outcomes of both procedures do not significantly differ; nevertheless, there may be a slight preference for a PRC [10]. A PRC is considered a reliable procedure with significant improvements in PRWE and DASH and preserved range of motion for the treatment of wrist arthritis and carpal trauma [25,26]. However, long-term outcomes in the follow-up of PRC can also be disappointing, with the possible progression of osteoarthritis in the lunate fossa due to malalignment of the neo-capitate-radial joint resulting in significant pain and reduction of hand function [27]. A 3-LT procedure may not completely halt the

ongoing osteoarthritis process or prevent conversion to salvage procedures [28]. However, we do believe that by restoring normal carpal kinematics, the 3-LT procedure will delay the course of normal progression of osteoarthritis in SLAC wrists [29], as shown in the postoperative radiographs (Figure 4). Thereby saving salvage procedures, such as a PRC, for later, since these are still feasible after a 3-LT is performed [5], and postponing its unfavorable long-term outcomes. As part of the shared decision-making process, the possibility of additional surgery should be pointed out to the patient.

In our study, the added value of 3-LT in SLAC patients seems to be limited to lower SLAC stages. In SLAC 1 and 2, the percentage of conversions to additional surgical procedures in the follow-up of 3-LT remains limited. During a median follow-up of 4.7 years (IQR 2.7 – 6.7 years), conversion was 11.2% and 18.2% respectively. However, patients classified with SLAC stage 3 converted more frequently, up to 50%. It is questionable whether performing a 3-LT in SLAC 3 is problem-solving, cost-effective, and therefore of added value. Due to the high conversion rate, we will be more cautious to offer 3-LT in SLAC 3. In these particular patients, 3-LT could still be useful to postpone additional osteoarthritis surgery, but with this study, these patients can be properly counseled.

Our study has several strengths. First, this study uses longitudinal clinical data. The information gathered represents the results of the 3-LT treatment as part of daily clinical care. During these routine outcome measures, we noticed that surgeons would sometimes choose to perform a 3-LT in a selected group of SLAC wrist patients. Secondly, with the current study, we contribute to a subject that has been scarcely reported in the literature. Performing a 3-LT (without radial styloidectomy) while SLAC is present is controversial and might therefore not have been described in the current literature.

Our study has several limitations. First, SLIL injury patients with SLAC treated with 3-LT had less pain and better hand function compared to patients with SLIL injury treated with 3-LT and patients who received a PRC (Table 1). This was unexpected since we hypothesized that patients with associated damage to the articular surface of the wrist would have more preoperative complaints. This indicates that surgeons most likely performed a 3-LT instead of a PRC in a selected group of SLIL injury patients that had less pain and functional problems. Understandably, surgeons are hesitant to perform a PRC when patients do not have pain and/or good hand function. However, this might lead to selection bias in our cohort. By using propensity score matching, we adjust for these preoperative differences, try to mitigate this bias, and compare groups that are equal at baseline. A future randomized controlled trial is the only way to prevent this bias and could in turn provide a definitive answer to our research question. Second, only a limited amount of people in the database were identified with a high classification of SLAC, stage 2 or 3, which implies that it is not a common procedure to perform a reconstructive treatment, like 3-LT, in the case of advanced osteoarthritis in the wrist. As a result, the statistical power of the analyses is too low to perform an analysis at the final time point. Nevertheless, with a difference of 15.1 points in PRWE between the 3-LT and PRC group at 1 year postoperatively, the trend indicates that PRC gives a faster and better improvement of symptoms than 3-LT in SLIL injury patients with higher SLAC stages.

In conclusion, change in PRWE after 3-LT does not significantly differ between matched SLIL injury patients and SLIL injury patients with SLAC after 1-year follow-up. Furthermore, the complication and conversion rates of SLAC 1 and 2 in the follow-up of 3-LT remain limited. Moreover, salvage treatments like PRC are always possible after a 3-LT procedure failed. Therefore, 3-LT can be considered a reconstruction treatment for early-stage SLAC wrists.

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Table Legends

Table 1. Baseline characteristics used for matching patients with SLIL injury and SLIL injury with SLAC treated with 3-LT.

Table 2. Baseline characteristics used for matching patients with SLAC stage 2/3 treated with 3-LT or PRC.

Table 3. Complications by ICHAW grade.

Figure Legends

Figure 1. Flowchart

Figure 2. Patient-Rated Wrist Evaluation (PRWE) scores.

Figure 3. Patient-Rated Wrist Evaluation (PRWE) scores.

Figure 4. PA and Lateral wrist X-ray six years post index surgery, 3-LT for SLAC 3A. There is a radiological progression of osteoarthritis visible, clinically the patient maintained all his activities.

Supplementary

Supplementary S1. Reversed Kaplan-Meier Plot

		Before matching (n = 311)			After matching (n = 146)		
	Level	**3-LT**	**3-LT + SLAC**	***p-value***	**3-LT**	**3-LT + SLAC**	***p-value***
Number of patients (n)		258	53		95	51	
Age (mean(SD)), years		47.46 (12.05)	52.06 (10.12)	0.010	52.25 (10.86)	51.33 (9.60)	0.613
Sex	F	114 (44.2)	17 (32.1)	0.141	42 (44.2)	16 (31.4)	0.182
	M	144 (55.8)	36 (67.9)		53 (55.8)	35 (68.6)	
Duration of symptoms (mean(SD)), months		21.92 (43.08)	27.98 (40.43)	0.347	25.26 (45.39)	25.31 (38.53)	0.995
Pain score at intake (mean(SD))		30.57 (10.51)	28.25 (11.18)	0.148	28.95 (10.65)	28.53 (10.90)	0.823
Function score at intake (mean(SD))		27.41 (11.76)	22.66 (13.57)	0.010	23.26 (11.19)	22.73 (13.31)	0.796
SLAC (%)	SLAC 0	258 (100.0)	0 (0.0)		95 (100.0)	0 (0.0)	
	SLAC 1	0 (0.0)	39 (73.5)		0 (0.0)	39 (76.5)	
	SLAC 2	0 (0.0)	11 (20.8)		0 (0.0)	10 (19.6)	
	SLAC 3	0 (0.0)	3 (5.7)		0 (0.0)	2 (3.9)	
Dominant hand (%)	No	114 (44.2)	23 (43.4)	1.000	48 (50.5)	28 (54.9)	0.741
	Yes	144 (55.8)	30 (56.6)		47 (49.5)	23 (45.1)	
Profession (%)	No	49 (19.0)	14 (26.4)	0.682	29 (30.5)	12 (23.5)	0.772
	Light	86 (33.3)	16 (30.2)		29 (30.5)	16 (31.4)	
	Moderate	65 (25.2)	12 (22.6)		17 (17.9)	12 (23.5)	
	Heavy	58 (22.5)	11 (20.8)		20 (21.1)	11 (21.6)	

Table 1. Baseline characteristics used for matching patients with SLIL injury and SLIL injury with SLAC treated with 3-LT.

		Before matching (n = 141)			After matching (n = 28)		
	Level	**PRC + SLAC 2/3**	**3-LT + SLAC 2/3**	***p-value***	**PRC + SLAC 2/3**	**3-LT + SLAC 2/3**	***p-value***
Number of patients (n)		127	14		18	10	
Age (mean(SD)), years		60.94 (9.61)	50.21 (11.14)	<0.001	57.11 (7.52)	55.40 (5.38)	0.532
Sex	F	38 (29.9)	6 (42.9)	0.589	8 (44.4)	5 (50.0)	1.000
	M	88 (69.3)	8 (57.1)		10 (55.6)	5 (50.0)	
	U	1 (0.8)	0 (0.0)		0 (0.0)	0 (0.0)	
Duration of symptoms (mean(SD)), months		41.24 (55.57)	49.50 (69.35)	0.608	24.89 (19.96)	35.30 (45.35)	0.405
Pain score at intake (mean(SD))		32.12 (9.89)	28.14 (9.69)	0.155	25.72 (11.56)	29.90 (9.45)	0.339
Function score at intake (mean(SD))		27.10 (11.49)	21.29 (13.47)	0.079	20.22 (11.16)	21.90 (15.26)	0.741
SLAC (%)	SLAC 2	117 (92.1)	11 (78.6)	0.239	15 (83.3)	8 (80.0)	1.000
	SLAC 3	10 (7.9)	3 (21.4)		3 (16.7)	2 (20.0)	
Dominant hand (%)	No	52 (40.9)	6 (42.9)	1.000	3 (16.7)	4 (40.0)	0.362
	Yes	75 (59.1)	8 (57.1)		15 (83.3)	6 (60.0)	
Profession (%)	No	59 (46.5)	4 (28.6)	0.263	6 (33.3)	4 (40.0)	0.880
	Light	23 (18.1)	5 (35.7)		6 (33.3)	2 (20.0)	
	Moderate	25 (19.7)	4 (28.6)		5 (27.8)	3 (30.0)	

	Heavy	20 (15.7)	1 (7.1)		1 (5.6)	1 (10.0)	

Table 2. Baseline characteristics used for matching patients with SLAC stage 2/3 treated with 3-LT or PRC.

	Grade 1			Grade 2	Grade 3
	Brace	Infection	Therapy	Injection	Surgery
SLAC 0	3%	2%	11%	13%	9%
SLAC 1	7%	0%	20%	7%	11%
SLAC 2	0%	0%	8%	15%	18%
SLAC 3	0%	0%	20%	0%	50%

Table 3. Complications by ICHAW grade.

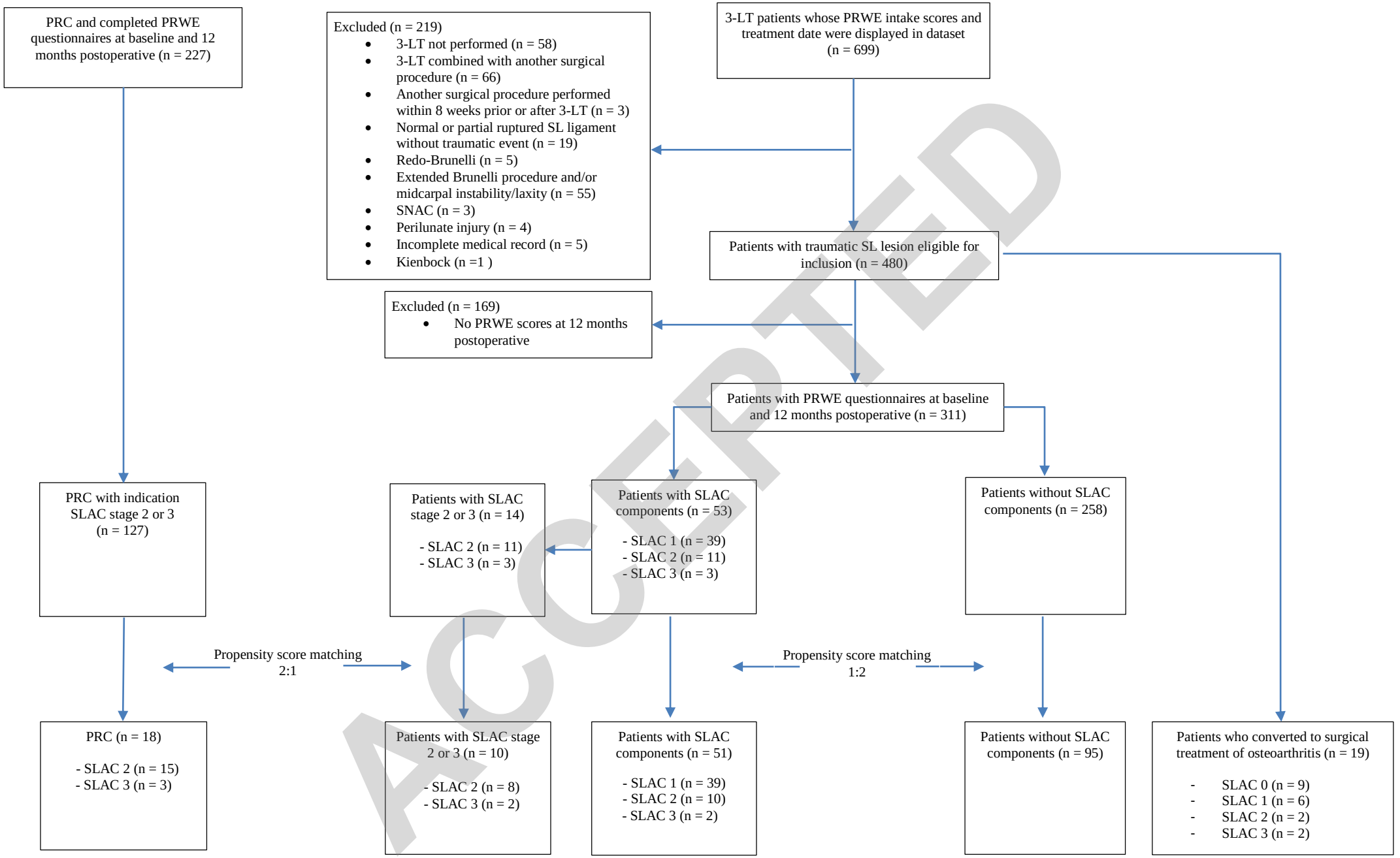

Figure 1. Flowchart

Figure 2

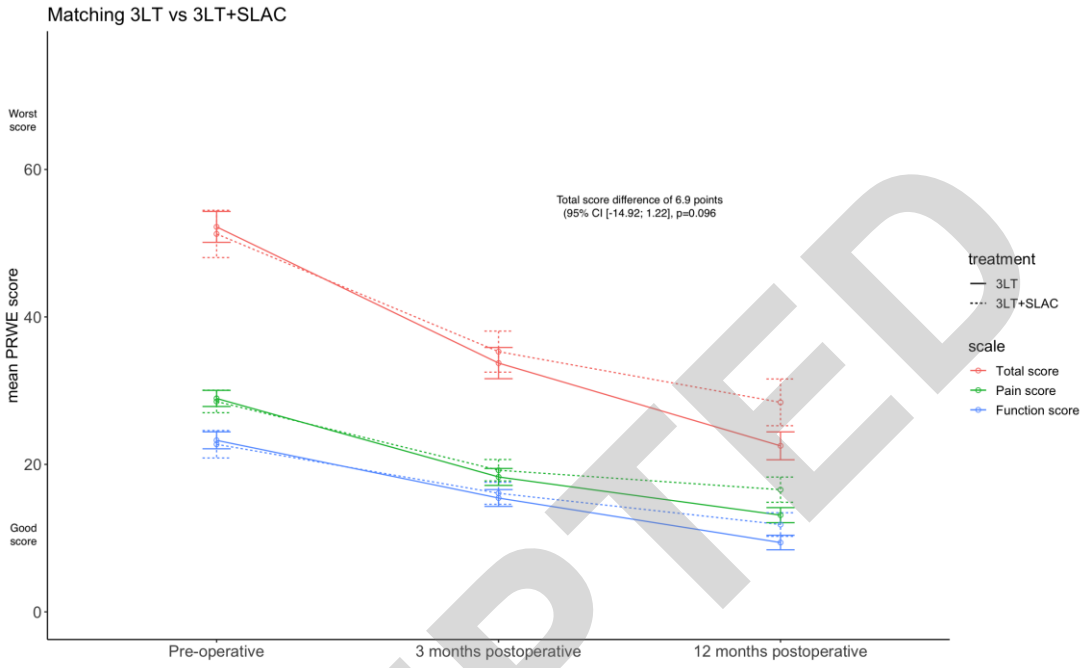

Figure 3

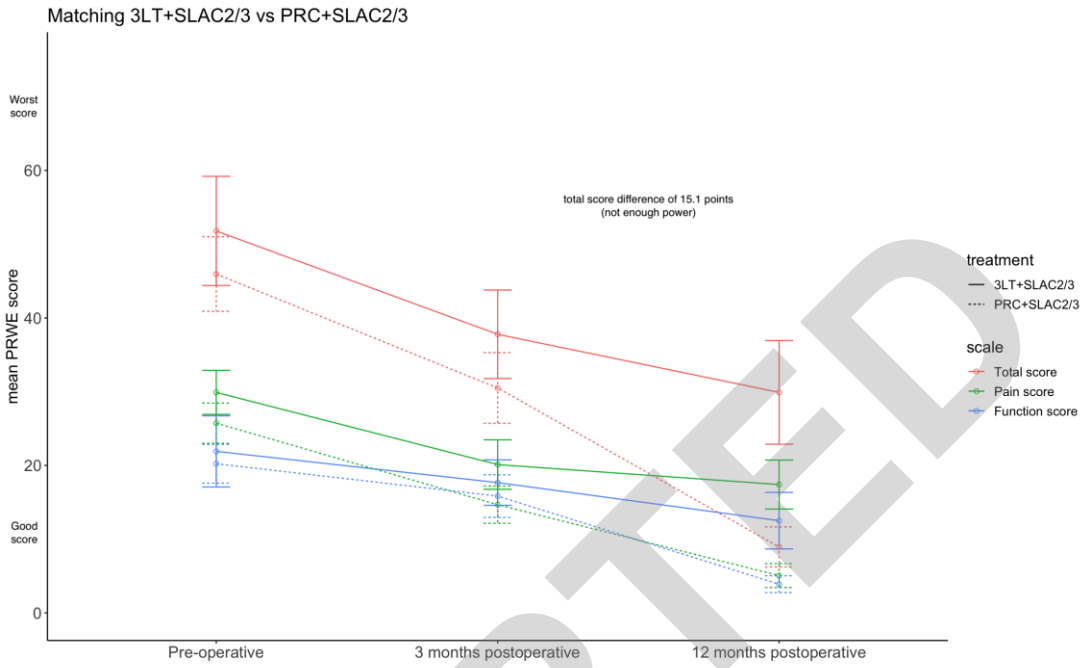

Figure 4

Suppl. Figure 1