SCIENTIFIC ARTICLE

Ligament Reconstruction Arthroplasty for Primary Thumb Carpometacarpal Osteoarthritis (Weilby Technique): Prospective Cohort Study

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Purpose The Weilby procedure is one of several accepted methods to treat primary thumb carpometacarpal osteoarthritis. We found no previous studies that included preoperative and postoperative subjective outcomes using validated questionnaires or preoperative and postoperative objective outcomes such as specific strength and range-of-motion measurements. Therefore, we performed a prospective cohort study in which we analyzed preoperative and postoperative objective and subjective outcomes after Weilby interposition tendoplasty.

Methods Nineteen patients (20 thumbs) with primary thumb carpometacarpal osteoarthritis were treated with Weilby interposition tendoplasty. For subjective assessment, the Disabilities of the Arm, Shoulder, and Hand (DASH) outcome data collection instrument was used to evaluate preoperative and postoperative outcomes at 0, 3, 6, and 12 months. Furthermore, patients completed a specific personal questionnaire at 12 months of follow-up. Objective assessments included interphalangeal joint flexion/extension; metacarpophalangeal joint flexion/extension; and carpometacarpal joint palmar abduction, opposition, and extension. Tip pinch, key pinch, 3-point pinch, and overall grip strengths were also measured. The measurements were performed preoperatively and at 3, 6, and 12 months after surgery. All complications were registered.

Results The DASH score was significantly improved, and 17 of 19 patients were satisfied with the procedure. The interphalangeal joint flexion/extension, metacarpophalangeal joint flexion/extension, and carpometacarpal joint extension did not significantly change. Carpometacarpal joint palmar abduction and opposition were significantly improved at 12 months. The tip pinch and key pinch strengths were increased but not significantly. The 3-point pinch and overall grip strengths were significantly improved at 12 months.

Conclusions The Weilby procedure is a reliable alternative to treat primary thumb carpometacarpal osteoarthritis without requiring bone tunnel creation. It achieves pain relief, stability, mobility, and strength. The objective and subjective outcomes of this study compare favorably with those of earlier reports of the Weilby procedure and are similar to the published results of the more commonly performed Burton-Pellegrini technique. *(J Hand Surg 2009;34A:1393–1401. Copyright © 2009 by the American Society for Surgery of the Hand. All rights reserved.)*

Type of study/level of evidence Therapeutic IV.

Key words Carpometacarpal, osteoarthritis, thumb, trapeziectomy, trapezium.

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Osteoarthritis at the base of the thumb can cause severe pain, weakness, and/or deformity and can result in marked disability. The main cause is weakening of the palmar beak ligament, resulting in increased metacarpal translation on the trapezium bone. In areas of high contact, shear stress forces can damage the articular cartilage, which can progress to degenerative osteoarthritis.[1,2]

A variety of surgical techniques has been described in which pain relief, stability, mobility, and strength are the main goals of treatment. In 1949, Gervis[3] originally described the concept of trapezial excision without suspension arthroplasty or tendon interposition. Several authors have reported excellent results of trapeziectomy alone[4–6] or in combination with tissue interposition.[7] However, trapeziectomy with or without tissue interposition has been criticized for weakening the thumb, because the procedure cannot prevent collapse of the first metacarpal bone.[8] In 1973, Eaton and Littler[9] described a method to reconstruct the volar beak ligament of a symptomatic hypermobile trapeziometacarpal joint without marked arthritis (Eaton and Littler stage I) by using the flexor carpi radialis (FCR) tendon. Based on the previous work of Gervis[3] and the work of Eaton and Littler,[9] several surgical techniques were described to restore function to the first ray, in which trapezium resection is combined with some form of suspension to support the thumb. The main goal of such suspensory ligament reconstruction is to maintain the trapezial height after resection of the trapezium bone and thus, at least theoretically, preserve thumb strength.[8]

In 1986, Burton and Pellegrini[8] described ligament reconstruction tendon interposition arthroplasty using the FCR tendon (Burton-Pelligrini technique). In this method, the trapezium is excised, and half of the FCR tendon is used as a tendon graft donor, being advanced through a bone tunnel at the base of the first metacarpal to support the thumb. The remaining tendon is rolled into a ball and interposed between the distal pole of the scaphoid and the base of the first metacarpal bone. In 1995, Tomaino et al.[10] reported the results of a long-term follow-up (8–11 years) of this technique, in which 95% of the patients had excellent pain relief and were satisfied with the outcome. Other authors reported similar results with techniques based on the Burton-Pelligrini technique.[11–13]

In 1978, Weilby[14,15] published an alternative technique that does not require bone tunnel creation at the base of the first metacarpal bone. In this procedure, the trapezium is removed, after which approximately one third of the FCR tendon is harvested and mobilized to its insertion on the second metacarpal base. Subsequently, the harvested tendon graft is used as a sling to wind together the abductor pollicis longus tendon and the remaining two thirds of the FCR tendon as a suspension and interposition arthroplasty. In 1988, Weilby[16] reported outcomes of the first 100 operated thumbs, of which 85% had complete pain relief. In 1987, Nylen et al.[17] reported similar results with this technique. These now 20-year-old studies of the Weilby procedure are retrospective studies, and they do not include preoperative and postoperative subjective outcomes using validated questionnaires or preoperative and postoperative objective outcomes such as specific strength and range-of-motion (ROM) measurements. Therefore, we performed a prospective cohort study in which we analyzed preoperative and postoperative objective and subjective outcomes after Weilby interposition tendoplasty. We hypothesized that the Weilby technique, which does not require bone tunnel creation, is a reliable alternative to treat primary thumb carpometacarpal osteoarthritis. After this procedure, pain relief, stability, mobility, and strength are obtained.

MATERIALS AND METHODS

Patients were enrolled in a prospective, single-arm study if they were diagnosed with primary thumb carpometacarpal osteoarthritis based on clinical and radiologic changes. The study was exempt from approval by the research review committee. Patients with rheumatoid or posttraumatic arthritis were excluded. Regardless of prior nonsurgical management such as splinting, exercise, physical therapy, treatment with nonsteroidal anti-inflammatory drugs, or intra-articular injections with steroids, all patients were initially treated with a removable splint for 3 months, and surgery was recommended only if the patient did not benefit from this management. None of the affected thumbs had been operated on previously, and none of the patients had a coexisting condition of the hand at the time of surgery. Indications for surgery were severe pain, loss of strength, and loss of motion of the base of the thumb causing marked disability during activities of daily living.

A power analysis showed that to achieve a power of 90%, a sample size of approximately 20 thumbs is recommended to detect a difference of 15.0 in the Disabilities of the Arm, Shoulder, and Hand (DASH) score with an estimated standard deviation of 20.0 and with a significance level (alpha) of .05 using a 2-sided 1-sample *t*-test. The difference of 15.0 and estimated standard deviation of 20 are based on a report by Gummesson et al.,[18] who showed that a mean DASH score change of 15 discriminates between improved and unimproved subjects. Accordingly, Weilby interposition tendoplasty was performed on 20 thumbs of 19 consecutive patients (12 left and 8 right; 2 men and 17 women) in 2005 and 2006. All patients were right-handed. The mean age was 58 years (range, 51–80 years). According to the radiographic criteria of Eaton and Glickel (1987),[19] preoperatively 4 thumbs exhibited stage II primary osteoarthritis; 10 exhibited stage III; and 6 exhibited stage IV with scaphotrapezial involvement.

Surgical procedure

The Weilby interposition tendoplasties were all performed by a single surgeon and were based on the original reports of Weilby.[14–16] Axillary block anesthesia was generally used, and surgeries were performed under tourniquet control. First, an incision was made along the radial border of the metacarpal of the thumb, after which the trapezium was removed. Great care was taken to avoid injury to the superficial radial nerve. A tendon strip about 10 cm in length and consisting of approximately one third of the width of the FCR tendon was dissected and tunneled to its insertion on the second metacarpal. This tendon graft was then intertwined in a figure-of-eight fashion (at least twice) around the abductor pollicis longus tendon and the rest of the FCR tendon, pulling those tendons together into the space created after excision of the trapezium bone. The figure-of-eight was locked by PDS 3-0 sutures (Ethicon Amersfoort, The Netherlands). The remaining tendon graft was wrapped upon itself as described by Carrol in 1987[20] and was interposed in the space left after the removal of the trapezium and pushed between the base of the first and second metacarpals. The joint capsule was closed, but K-wires were not inserted to stabilize the thumb. The thumb was immobilized in a spica cast for 4 weeks, after which the cast was replaced with a removable protective splint, and physiotherapy was started by a hand therapist.

Subjective assessment

The DASH outcome data collection instrument (Dutch Language Version) was used to evaluate preoperative and postoperative outcomes at 0, 3, 6, and 12 months. For further subjective assessment, all patients completed a nonvalidated specific personal questionnaire at 12 months of follow-up (Table 1).

Objective assessment

The following ROM measurements were assessed preoperatively and at 3, 6, and 12 months of follow-up: interphalangeal (IP) joint flexion/extension, metacarpophalangeal (MCP) joint flexion/extension, and carpometacarpal (CMC) joint palmar abduction (first web space) measured using the intermetacarpal distance in centimeters. To calculate the intermetacarpal distance, the thumb was placed in full palmar abduction, the easily identifiable mid-dorsal points on the subcutaneous surface of the first and second metacarpal heads were marked, and the separation between these was measured.[21]

Additional CMC joint opposition was measured using the Kapandji score (0 to 10), and CMC joint extension was measured in centimeters with the thumb in maximum radial abduction.

The strength measurements tip pinch strength, key pinch strength, and 3-point pinch strength were measured using a Baseline pinch gauge (Biometrics Ltd E-link H500 Hand Kit; Gwent, UK). The overall grip strength was measured using a Baseline hydraulic hand dynamometer (Biometrics Ltd E-link H500 Hand Kit).

All ROM and strength measurements were carried out by an independent hand therapist in accordance with a strict, well-defined, published protocol.[21,22]

TABLE 1. Specific Personal Questionnaire

	Number of Patients	Percentage (%)
Pain		
No pain	10	53
Seldom	5	26
After forceful activities	3	16
Rest pain	1	5
Night pain	0	0
Pain level		
Improved	17	90
Not improved	2	11
Worse	0	0
Willingness to have the surgery again under similar circumstances		
Yes	17	90
No	2	11
Overall satisfaction		
Excellent	9	47
Good	6	32
Acceptable	2	11
Fair	1	5
Poor	1	5

Note: Percentages in categories may total more than 100% because of rounding.

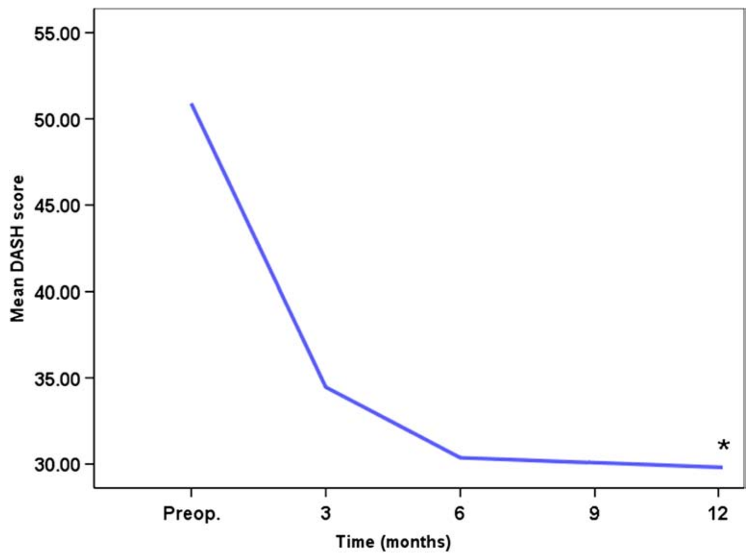

FIGURE 1: The mean preoperative DASH score was 51 (range, 21–72.5; SD, 14.8), 3 months postoperative was 36 (range, 1.6–59.1; SD, 17.1), 6 months postoperative was 30.5 (range, 1.6–62.5; SD, 16.7), and 12 months postoperative was 30 (range, 3–61; SD, 18.8). *Significantly improved value from preoperative clinical evaluations ($p < .001$).

All complications after surgery were registered in a separate database for a period of 12 months.

Statistical analysis

The changes from preoperative clinical evaluations at 12 months of follow-up for the various outcome measures were analyzed separately using a paired *t*-test. All tests were 2-sided, and differences were accepted as statistically significant with $p < .05$.

RESULTS

Subjective outcomes

The mean preoperative DASH score was 51 (0 = no disability, 100 = maximum disability). At 3 months follow-up, the mean DASH score was 36, at 6 months it was 30.5, and at 12 months it was 30. The DASH score significantly improved ($p < .001$; Fig. 1). Detailed values are given in Table 2. The specific personal questionnaire at 12 months of follow-up showed that 17 of 19 patients had an improved pain level compared with that of the preoperative situation. Furthermore, 10 of 19 patients had complete pain relief, 5 patients reported no more than occasional ache, 3 patients reported mild pain with forceful activities, and 1 patient reported pain at rest. Seventeen of 19 patients responded that they would have the surgery again under similar circumstances. The results of the overall satisfaction rating showed that 9 of 19 patients had an excellent result, 6 patients had a good result, 2 patients had an acceptable result, 1 patient had a fair result, and 1 patient had a poor result. Detailed values are given in Table 1.

TABLE 2. Analysis of the Change in DASH Score From Preoperative Clinical Evaluations Shows a Significantly Improved DASH ($p < .001$)

	Paired Differences*					
				95% Confidence Interval of the Difference		
	Mean	SD	SEM	Lower		Upper
DASH 0 to DASH 3	−14.93	9.63	2.27	−10.14	to	−19.72
DASH 0 to DASH 6	−20.54	14.58	3.26	−13.71	to	−27.36
DASH 0 to DASH 12	−20.83	20.09	4.49	−11.42	to	−30.23

*Paired differences of the DASH scores. DASH 0 is mean DASH score preoperative, DASH 3 is mean DASH score at 3 months, DASH 6 is mean DASH score at 6 months, and DASH 12 is mean DASH score at 12 months.

Objective outcomes

Interphalangeal joint flexion/extension ($p = .972$; $p = .950$) and MCP joint flexion/extension ($p = .200$; $p = .545$) did not significantly change postoperatively. Preoperative CMC joint palmar abduction measured using the intermetacarpal distance was 5.4 cm. At 3 months of follow-up, the intermetacarpal distance had increased to 6.1 cm and at 6 months to 6.2 cm. At 12 months of follow-up, the intermetacarpal distance slightly decreased to 5.9 cm, but the net increase remained signif-

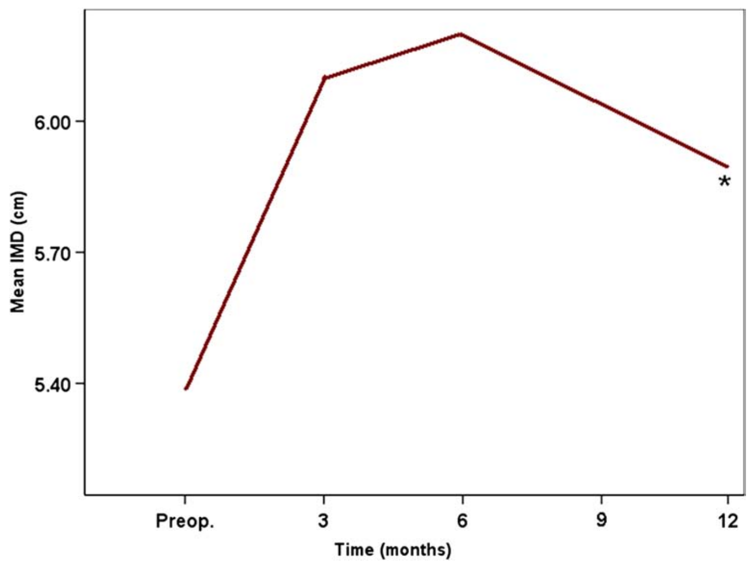

FIGURE 2: The mean preoperative intermetacarpal distance (cm) was 5.4 (range, 3.5–6.7; SD, 0.9), 3 months postoperative was 6.1 (range, 4.8–8.0; SD, 0.8), 6 months postoperative was 6.2 (range, 4.2–7.5; SD, 0.8), and 12 months postoperative was 5.9 (range, 4.0–7.0; SD, 0.7). *Significantly improved value from preoperative clinical evaluations (p = .011). IMD, intermetacarpal distance.

TABLE 3. Significantly Improved Objective Outcomes at 12 Months of Follow-Up

	Paired Differences*						
				95% Confidence Interval of the Difference			
	Mean	SD	SEM	Lower		Upper	p Value
IMD 0 to IMD 12	0.51	0.82	0.18	0.13	to	0.89	.011
Kapandji 0 to Kapandji 12	0.85	1.59	0.36	0.11	to	1.59	.027
TPP 0 to TPP 12	0.80	1.56	0.35	0.07	to	1.53	.034
OG 0 to OG 12	3.07	5.11	1.14	0.68	to	5.46	.015

*Paired differences of the IMD (intermetacarpal distance), Kapandji score, TPP (3-point pinch strength), and OG (overall grip strength) at 12 months follow-up.

icant compared with the preoperative value (p = .011) (Fig. 2, Table 3). Preoperative thumb opposition measured using the Kapandji score was 8.3. The Kapandji score showed a significant improvement at 12 months of follow-up with a mean score of 9.2 (p = .027) (Fig. 3, Table 3). Carpometacarpal extension did not change significantly (p = .991). The strength measurements at 12 months of follow-up showed that the tip pinch strength increased but not significantly (mean preoperative = 4.3 kg; final follow-up = 4.4 kg; p = .915). The key pinch strength was increased as well, but also not significantly (mean preoperative = 5.3 kg; final follow-up = 5.6 kg; p = .642). The 3-point pinch strength was significantly improved at 12 months of follow-up, with a mean of 5.0 kg (preoperative 4.2 kg; p = .034) (Table 3). The overall grip strength was significantly improved at 12 months of follow-up, with a mean of 21.0 kg (preoperative 17.9 kg; p = .015) (Table 3). Figure 4 shows the tip pinch, key pinch, and the 3-point pinch strengths. Figure 5 shows the overall grip strength results.

Complications

Two patients experienced temporary paresthesia in the distribution of the superficial sensory branch of the radial nerve. One patient reported sensory loss of the palmar branch of the superficial radial nerve at the final follow-up, but this did not affect the patient's objective and subjective outcomes. No reflex sympathetic dystrophy occurred during this study. One patient reported de Quervain's disorder, but the symptoms disappeared after an injection of steroids. Despite extensive conservative management and supervised hand therapy, 1 patient experienced pain at rest and impaired hand function at the 12-month examination. Radiographic analysis showed new radiocarpal degenerative changes in the wrist, which explained the impaired hand function; however, the patient declined further surgical management.

DISCUSSION

The earlier reports of the Weilby procedure were retrospective studies that did not include standardized outcome measures. The results in the study of Nylen et

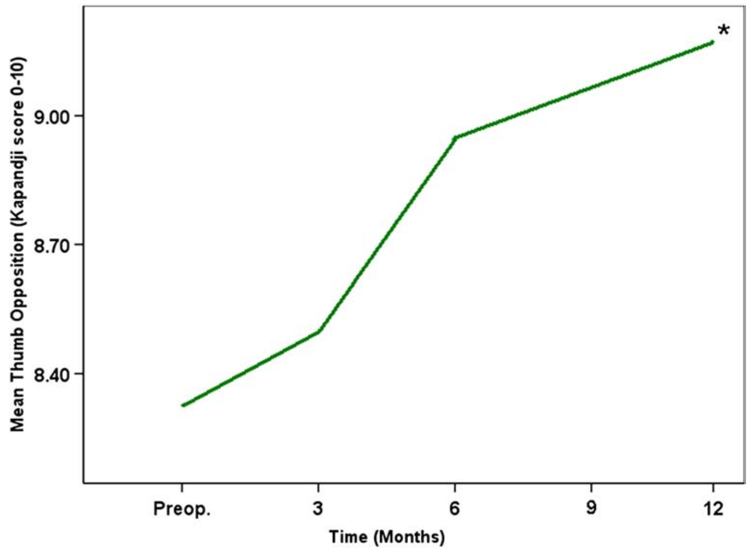

FIGURE 3: The mean preoperative thumb opposition (Kapandji score, 0–10) was 8.3 (range, 4–10; SD, 2.0), 3 months postoperative was 8.5 (range, 5–10; SD, 1.5), 6 months postoperative was 9.0 (range, 4–10; SD, 1.4), and 12 months postoperative was 9.2 (range, 8–10; SD, 0.8). *Significantly improved value from preoperative clinical evaluations (p = .027).

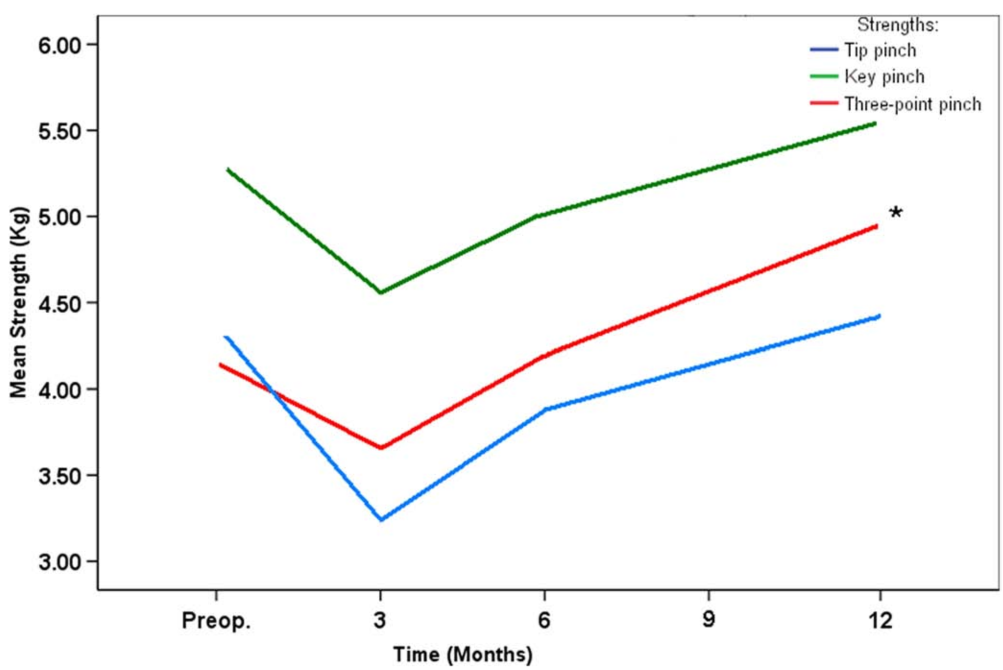

FIGURE 4: The mean tip pinch strength (kg) preoperatively was 4.3 (range, 1.0–12.5; SD, 4.14), 3 months postoperative was 3.2 (range, 0.8–6.6; SD, 1.47), 6 months postoperative was 3.9 (range, 1.3–9.0; SD, 1.67), and 12 months postoperative was 4.4 (range, 2.3–7.8; SD, 1.53). The key pinch strength (kg) preoperatively was 5.3 (range, 1.8–11.0; SD, 2.81), 3 months postoperative was 4.6 (range, 1.6–10.0; SD, 1.91), 6 months postoperative was 5.0 (range, 2.5–9.1; SD, 1.60), and 12 months postoperative was 5.6 (range, 3.1–7.6; SD, 1.21). The 3-point pinch strength (kg) preoperatively was 4.2 (range, 1.0–9.6; SD, 2.29), 3 months postoperative was 3.7 (range, 1.0–7.0; SD, 1.53), 6 months postoperative was 4.2 (range, 1.7–8.3; SD, 1.66), and 12 months postoperative was 5.0 (range, 2.7–7.3; SD, 1.36). *Significantly improved value from preoperative clinical evaluations (p = .034).

al.[17] included overall satisfaction, pain relief, and return-to-work and complication rates. The results in the study of Weilby[16] included pain relief, ROM, and strength measurements compared with those of the contralateral thumb and complication rates. Our prospective cohort study included preoperative and postopera-

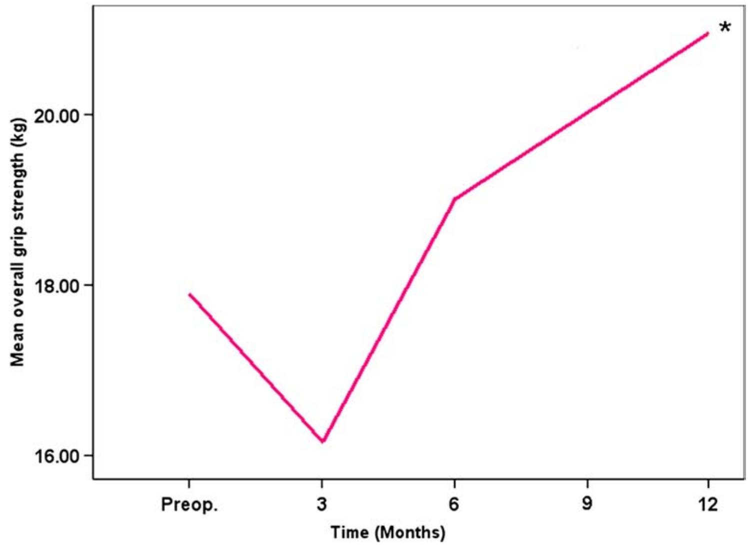

FIGURE 5: The mean overall grip strength (kg) preoperatively was 17.9 (range, 1.5–43.3; SD, 9.93), 3 months postoperative was 16.2 (range, 3.8–36.6; SD, 9.42), 6 months postoperative was 19.0 (range, 8.3–38.6; SD, 8.12), and 12 months postoperative was 21.0 (range, 11.5–40.6; SD, 7.91). *Significantly improved value from preoperative clinical evaluations (p = .015).

tive subjective outcomes assessed by the DASH score and a specific personal questionnaire. A study by De Smet et al.[23] showed the DASH score to be a valuable tool to evaluate the outcome of surgical treatment for osteoarthritis at the base of the thumb. Furthermore, our study includes preoperative and postoperative objective outcomes assessed by both specific ROM and strength measurements, as well as complication rates.

Analysis of the subjective outcomes of our patients showed a mean preoperative DASH score of 51 points. This is similar to the results of the study by De Smet,[23] who reported a mean DASH score of 47 points preoperatively in 15 patients with osteoarthritis at the base of the thumb. The postoperative DASH score in our study was significantly reduced compared with the preoperative value, with a mean score of 30 at the 12-month follow-up ($p < .001$). These results are similar to another study by De Smet et al.[24] that compared the outcomes of trapeziectomy without interposition or postoperative K-wire fixation versus trapeziectomy with ligament reconstruction and tendon interposition (ie, Burton-Pelligrini technique) in a prospective study. The first group had a postoperative mean DASH score of 33 (range, 0–77; SD, 29.6), and the second had a DASH score of 27 (range, 0–94; SD, 22.8) with a mean follow-up of 34 months.[24] Our DASH score measurements were also decreased at 3 and 6 months of follow-up. As reported by Gummesson et al.,[18] a mean DASH score change of 15 discriminates between improved and unimproved subjects. The mean DASH score change in the current study was 15 points at 3 months of follow-up, 20.5 points at 6 months of follow-up, and 21 points at 12 months of follow-up (Table 2), which implies a significant improvement in perceived functional disability as early as 3 months ($p < .001$).

The results of the analysis of the specific personal questionnaire showed that 79% of the patients reported no more than an occasional ache, and 16% reported mild pain only with forceful activities. Only 1 patient had pain at rest (5%). These values are consistent with findings of the 1988 study of Weilby,[16] who reported that 85% of patients became free of pain and 15% had symptoms after strenuous work. Our results also showed that 90% of our patients were satisfied with the procedure (90% would have the surgery again; 90% had an improved pain level; 90% rated their overall satisfaction as excellent, good, or acceptable). Nylen et al.[17] reported that only 73% of their patients were satisfied with the Weilby procedure; 27% were not. Our patient-satisfaction rating of 90% compares favorably with that of Nylen et al.[17] and is in line with those reported by randomized controlled studies of the more commonly performed Burton-Pelligrini technique (De Smet et al.[24] reported 90% patient satisfaction; Kriegs-Au et al.[13] reported 85%).

Measurement of the CMC joint palmar abduction (first web space) in most studies was done by determining the thumb web space simply by measuring angles. We used the intermetacarpal distance because a study by Murugkar et al.[21] reported that the inter-rater reliability of the intermetacarpal distance is higher than that of angle measurements. The results of the intermetacarpal distance in our study showed that the first web space was significantly improved at 12 months of follow-up (mean intermetacarpal distance increased by 10%; $p = .011$). Measurements of thumb opposition using the Kapandji score demonstrated that CMC opposition was also significantly improved at 12 months (mean Kapandji score = 9.2, and 17 of 20 thumbs (85%) were able to touch the palmar crease of the little finger with the thumb tip; $p = .027$). Range-of-motion measurements in a randomized controlled study by Kriegs-Au et al.[13] with a mean follow-up of 48 months showed in the Burton-Pelligrini technique group an improvement of the first web space of approximately 16% (using angle measurement), and only 9 of 16 thumbs (56%) were able to touch the palmar crease of the little finger with the thumb tip.

In the current study, strength measurements showed that both tip pinch and key pinch strength were increased and that 3-point pinch and overall grip strength were significantly increased postoperatively at 12 months compared with that at preoperative evaluations ($p = .034$; $p = .015$). A recent, randomized controlled study by Field and Buchanan[25] showed in their Burton-Pelligrini technique group at 12 months of follow-up a tip pinch strength, a key pinch strength, and an overall grip strength of 3.8, 4.9, and 22.0 kg, respectively (the corresponding values in our study were 4.4, 5.6, and 21.0 kg).

At 3 months follow-up of our patients' strength measurements (tip pinch, key pinch, 3-point pinch, and overall grip) showed decreased values compared with the preoperative values (Figs. 4, 5). After the third month, the strength increased, and at the 12-month follow-up all of the strength measurements had improved from the preoperative evaluations. Although the strength measurements were decreased at 3 months, the DASH score after 3 months had improved by 15 points. As noted above, because a mean DASH score change of 15 points discriminates between improved and unimproved subjects,[25] the observed reductions in strength measurements did not affect the patients' subjective outcomes after 3 months.

The complication rate we observed over the 12-month study period is consistent with those of the studies of Field et al.[23] and Kriegs-Au et al.[13] (Burton-Pelligrini technique). Those authors also noted temporary paresthesia in the distribution of the superficial sensory branch of the radial nerve. Furthermore, they reported a few patients with severe reflex sympathetic dystrophy that sometimes resulted in impaired hand function at the final follow-up. In our study, one patient had impaired hand function at the 12-month follow-up caused by radiocarpal degenerative changes. Our complication rates compare favorably with the earlier study of Nylen et al.[17] (Weilby procedure). They reported 15 complications of surgery in 89 arthroplasties (5 patients had reflex sympathetic dystrophy, 2 patients had transient edema, 1 patient had trigger thumb, 3 patients had carpal tunnel compression, and 4 patients had loss of first metacarpal abduction).[17] Weilby[16] reported that 7% of his patients developed de Quervain's disorder and suggested that a routine release of the first extensor compartment during the procedure could prevent de Quervain's disorder. We do not recommend this because we observed only one episode of de Quervain's disorder after 12 months of follow-up, and it responded very well to an injection of steroids.

A limitation of the current study is that it had only a single arm. Therefore, we compared our results by reviewing the literature. Furthermore, our study had a relatively short follow-up of 12 months, and additional prospective randomized studies with longer follow-up periods are needed.

Based on the results of this study, we conclude that the Weilby procedure is a reliable alternative technique that avoids bone tunnel creation with results similar to those reported for the more commonly performed Burton-Pelligrini technique.

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