Reconstruction of swan neck deformities after proximal interphalangeal joint arthroplasty

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Abstract

Background The authors report the use of a single slip of the flexor digitorum superficialis (FDS) as a hemitenodesis through the A2 pulley in treating swan neck deformities after previous unconstrained proximal interphalangeal joint (PIP) arthroplasty.

Methods A retrospective chart review was undertaken to identify non-constrained PIP joint arthroplasties that underwent a subsequent soft tissue hemitenodesis for swan neck deformities. The range of motion (ROM), implant design, preoperative diagnosis, and surgical approach were collected. The Michigan Hand Outcomes Questionnaire and patient satisfaction questionnaire were collected.

Results There were 12 patients with 14 procedures reviewed. There were seven surface replacement arthroplasties (SRA) (cobalt chrome on polyethylene) and eight pyrocarbon prostheses. The primary diagnosis for the initial joint arthroplasty was osteoarthritis (8), post-traumatic (2), and rheumatoid arthritis (5). The primary dorsal approach was a longitudinal split in eleven cases, Chamay in two, and unknown in one case. Nine of the 14 revision procedures had a concomitant dorsal approach to the joint. The average final position intraoperatively was 24.2° of flexion (range 15°–40°). Final ROM was 39° with average follow-up of 30 months. The average postoperative radiographic position was 20.3° flexion with an average of 24.8° hyperextension preoperatively. There was one failure secondary to implant loosening requiring fusion.

Discussion For patients with a swan neck deformity after PIP arthroplasty, a FDS hemitenodesis provides a treatment option with a low revision rate, retained motion, and maintenance of the original implant with no shortening of the digit.

Keywords Arthroplasty · FDS · Hemitenodesis · PIP · Swan-neck

Introduction

Small joint arthroplasty is an established treatment for arthritis of the proximal interphalangeal (PIP) joint. Several different types of implants are available for the surgeon and commonly include hinged silicon, unconstrained pyrocarbon, and metal-plastic prostheses. Unfortunately, small joint arthroplasty has not enjoyed the same predictable success of large joint arthroplasty and reoperation rates range of 6–58 % [1, 5–9, 11, 12, 14–16]. Common causes of failure and reoperation include loosening, instability, and limited range of motion. Fixed swan neck deformity can also occur and result in significant dysfunction following PIP arthroplasty [14]. Interestingly, many of these patients seldom complain of pain, and they complain more of functional limitation secondary to the position of their finger and loss of motion. Revision arthroplasty and arthrodesis are two treatment options for this problem and unfortunately carry significant risks and complications including implant failure, potential digital shortening, and non-union [10, 14]. Prior publications have discussed the management of swan neck deformities in patients with rheumatoid arthritis, cerebral palsy, and post-traumatic deformities using a flexor digitorum superficialis (FDS) tenodesis [2, 13]. We hypothesize that using a FDS hemitenodesis, with or without extensor tendon V-Y lengthening, for the treatment of swan neck deformities following unconstrained PIP joint arthroplasty will result in the maintenance of a functional position with a low revision rate.

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Materials and methods

Following Institutional Review Board approval, a retrospective chart review was undertaken to identify non-constrained proximal interphalangeal (PIP) joint arthroplasties, with subsequent swan neck deformities, that underwent a subsequent soft tissue hemitenodesis for swan neck deformity. Between 2001 and 2010, a total of 334 PIP arthroplasties in 250 patients were performed. Forty were treated with constrained silicone implants and 294 were treated with non-constrained implants (203 pyrolytic carbon and 91 metal-plastic). The female–male ratio was 164:96. Diagnoses included 166 with post-traumatic or osteoarthritis and 84 with inflammatory arthritis. The average age at the time of surgery was 57 years.

Twelve patients with 14 joints identified that underwent a partial FDS hemitenodesis for a post PIP arthroplasty swan neck deformity between 2001 and 2010. The range of motion (ROM), implant design, preoperative diagnosis, and surgical approach were collected from the charts (Table 1). The Michigan Hand Outcomes Questionnaire [4] and a generalized patient satisfaction questionnaire were mailed to the patients as well as consent forms. No questionnaire data was utilized unless the patient completed and signed a consent form. The specific prostheses design utilized for each case was based on the primary surgeon's preference.

The surgical technique creates a PIP tether based on a single slip of the FDS which can create a soft-tissue constraint to maintain the finger in a functional position (Fig. 1). A volar approach is used to gain access to either the distal limb of the ulnar or radial flexor digitorum superficialis. After the preferred limb of the FDS has been identified, it is followed proximal to the A2 pulley and released from the FDS proper to create a 2–4-cm FDS leash that is still attached distally to

the middle phalanx. Next, a small transverse cut is made in the A2 pulley and the newly created FDS slip is tunnelled from deep to superficial through the newly created cut in the A2 pulley. The finger is then placed in approximately 25° of flexion and the free slip of the FDS, now outside of the tendon sheath, is folded back distally towards its insertion and is sewn back onto itself and the A2 pulley with a non-absorbable stitch. Our preference is a 2–0 Ticron (Covidien Mansfield, MA) suture. If unable to place the finger in a functional flexed position, an additional dorsal incision can be utilized to lengthen the extensor mechanism, release the PIP joint and help accommodate the newly created flexed position. We have found that based on the flexibility of the extensor mechanism after correction of the swan neck deformity, the extensor mechanism may need to be lengthened in a V-Y fashion. A Chamay type of approach more readily lends itself to allow an easier V-Y lengthening and closure [3] (Fig. 2). The final desired position of flexion upon completion of the procedure is 25° (Fig. 3). The patient is typically immobilized in this position of flexion for 4 to 6 weeks. Thereafter, active range of motion is initiated. Aside from a single meeting with a therapist to fabricate a removable splint and demonstrate some exercises, the patients did not undergo any formal structured hand therapy and were allowed to progress their motion as tolerated.

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008 (5). Informed consent was obtained from all patients for being included in the study.

Results

There were 12 patients with 14 fingers who met the inclusion criteria for this study (Table 1). Seven were surface replacement arthroplasties (SRA, cobalt chrome on polyethylene) and seven pyrocarbon prostheses. The primary diagnosis for the initial joint arthroplasty was osteoarthritis (7), post-traumatic (2), and rheumatoid arthritis (5). The radial limb of the FDS was utilized in two procedures, the ulnar in 12. Nine of the 14 procedures had a concomitant dorsal approach to the joint, with 7/9 utilizing a Chamay approach while the remaining two utilized a longitudinal approach. Five of the nine dorsal approaches underwent an associated formal V-Y lengthening of the extensor mechanism. Each lengthening had a Chamay dorsal exposure. The average final position intraoperatively was 24.2° of flexion measured from full extension (range 15°–40°). Two of the 14 digits underwent component revision with one revision involving the proximal component (SRA) only and one revision involving the distal component only (pyrocarbon). Final ROM data was available for 11/14 digits (range 5.2°–90°; average 39.4°) (Table 2).

Table 1 Patient demographics and operative history

Primary extensor approach	Secondary EVY	Lengthening	FDS sleeve
Longitudinal	Chamay	No	Ulnar
Longitudinal	None	NA	Radial
Longitudinal	Longitudinal	No	Ulnar
Chamay	Chamay	No	Ulnar
Chamay	Chamay	Yes	Ulnar
Longitudinal	Chamay	Yes	Ulnar
Longitudinal	Chamay	Yes	Radial
Longitudinal	None	NA	Ulnar
Longitudinal	None	NA	Ulnar
Longitudinal	Chamay	Yes	Ulnar
Unknown	None	NA	Ulnar
Longitudinal	Chamay	Yes	Ulnar
Longitudinal	None	NA	Ulnar
Longitudinal	Longitudinal	No	Ulnar

Fig. 1 **a** Identification of the ulnar slip of the FDS. **b** Isolation of the single FDS slip after it has been released proximally. **c** Passage of the FDS slip through the mid-substance of the A2 pulley. **d** Repair of the FDS slip back onto itself with a non-absorbable suture

Final follow-up averaged 30 months and ranged from 1 to 74 months. Preoperative and postoperative X-rays were available on 11 of 14 digits and showed an average radiographic change from 24.8° of extension to 20.3° of flexion. Seven of the 12 patients (eight digits) completed a satisfaction survey and the Michigan Hand Outcomes Questionnaire with the average reported pain scale score of 2 (Table 3). Post-operative complications included one suture reaction requiring removal in clinic, an early hyperextension deformity reoccurrence corrected with extended post-operative splinting, and one case of ulnar-sided finger paresthesias that had resolved by one year post-operatively. This patient had an ulnar-based FDS hemitenodesis. One patient went on to fusion 4 years after hemitenodesis due to component loosening and extensive bone loss.

Discussion

Small joint arthroplasty is an established treatment option for PIP arthritis. The development of a swan neck deformity after PIP arthroplasty is a seldom-discussed complication that often times leaves the surgeon and patient with few options. Prior to considering surgery for fixed swan neck deformities, an extensive non-operative treatment plan is utilized with an understanding that the best treatment is prevention. A heightened awareness of this possibility during the recovery and rehabilitation is well established with the rehabilitation protocol. Following PIP arthroplasty, the patient is placed in a splint holding the joint in extension with care taken to avoid hyperextension for 5–7 days. Therapy is then initiated and depending on the stability of the construct and the patients underlying diagnosis, static splinting and a short-arc protocol is initiated.

Fig. 2 **a** Dorsal Chamay approach for the proximal interphalangeal joint. **b** Completion of the Chamay incision with reflection of the extensor mechanism. **c** V-Y closure of the incision resulting in a lengthened extensor mechanism. **d** Final resting position after hemitenodesis and dorsal V-Y lengthening

Fig. 3 **a** Final resting position intra-operatively after FDS hemitenodesis and an associated dorsal V-Y lengthening. **b** Pre-operative swan neck deformity in the right ring (#4) digit. **c** Five-year post-operative lateral X-ray of ring (#4) finger FDS hemitenodesis

In the first week or two, the focus is on edema control and obtaining a 0°–30° arc of motion. Hyperextension of the PIP joint must be avoided and tendencies should be addressed as soon as possible. After about 2–3 weeks, incremental increases in arc of motion at 10°–15° intervals are performed. The goal is to achieve 80°–90° by 8 weeks following surgery. Thereafter, the patient may start strengthening. In cases where the patient develops or begins to develop a tendency toward hyperextension, extension block splints preventing extension beyond 10°–15° of flexion, but allowing for continued flexion are utilized. Therapy protocols are modified to avoid extension stressing with the understanding that a flexion contracture may result and need to be addressed at a later date. However, flexion contractures are more readily manageable in the authors' opinion than swan neck deformities.

Revision implantation and arthrodesis may be successful in treating this problem, but these are significant procedures that involve risk of increased bone loss, non-union, and finger shortening [10, 14]. In addition, if the patient has no pain, a simpler, less invasive treatment that allows the patient to otherwise keep the implant is attractive. The authors believe the use of a FDS hemitenodesis is a valid option for the care of this specific patient subset.

The use of a FDS tenodesis has been used to manage swan neck deformities in a breadth of patients. Swanson originally discussed his experience in using a FDS tenodesis fixed with drill holes through the middle phalanx to manage patients with cerebral palsy [15]. He advocated tensioning the finger in 20°–30° of flexion, and reported good outcomes in six patients with a minimum follow-up of 4 years. Nalebuff has also supported the use of a FDS hemitenodesis in the management of patients with rheumatoid arthritis [13]. More recently,

Table 2 Post FDS hemitenodesis evaluation

Patient	Follow-up (months)	Extension (degrees)	Flexion (degrees)	ROM (degrees)	Revision
1	48	46	57	11	Yes/ fusion
2	47	7	88	81	No
3	32	83.9	89.1	5.2	No
4 (a)	15	55	70	15	No
4 (b)	15	50	65	15	No
5 (a)	4	40	Not available	Not available	No
5 (b)	4	40	Not available	Not available	No
6	29	10	23	13	No
7	74	13	68	55	No
8	1	0	65	65	No
9	67	24	79	55	No
10	3	Not available	Not available	20	No
11	24	5	95	90	No
12	10	12	60	48	No

Table 3 Patient satisfaction and Michigan Hand Outcomes Questionnaire results

Patient	Current pain	Pain compared with before hemitenodesis	Function compared with before hemitenodesis	Appearance Compared with before arthrodesis	Satisfaction	Willingness to undergo procedure again	MHQ surgical hand	MHQ nonsurgical hand	Workman's compensation
1	0	Significantly better	Significantly better	Somewhat better	Very satisfied	Definitely yes	42	47	No
2	0	Significantly better	Significantly better	Significantly better	Very satisfied	Definitely yes	65	60	No
3	–	–	–	–	–	–	–	–	–
4 (a)	1	Same	Somewhat better	Somewhat better	Somewhat satisfied	Probably yes	82	95	No
4 (b)	1	Same	Somewhat better	Somewhat better	Somewhat satisfied	Probably yes	89	96	No
5 (a)	–	–	–	–	–	–	–	–	–
5 (b)	–	–	–	–	–	–	–	–	–
6	–	–	–	–	–	–	–	–	–
7	1	Significantly better	Significantly better	Somewhat better	Very satisfied	Definitely yes	85	69	No
8	3	Somewhat worse	Significantly worse	Significantly worse	Very disappointed	Definitely not	70	95	Yes
9	1	Somewhat better	Somewhat worse	Somewhat worse	Somewhat satisfied	Unsure	67	75	No
10	7	Significantly worse	Significantly worse	Significantly worse	Very disappointed	Unsure	41	90	Yes
11	–	–	–	–	–	–	–	–	–
12	–	–	–	–	–	–	–	–	–

Catalano and colleagues describe their experience using a flexor hemitenodesis in the management of chronic post-traumatic swan neck deformities [2]. In a series of 12 patients, 10 had good or excellent results at an average follow-up of 35 months and all 12 returned to their previous level of employment. Though each surgeon has used a slight variation on their techniques to create the flexor tenodesis, the basic principle is consistent, to help keep the PIP joint in a biomechanically favorable position, and thus place the finger in a more cosmetic and functional position for the patient.

Complications with unconstrained PIP joint arthroplasties can be challenging to manage. Patients that present with a swan neck deformity have limited options. One option is a revision arthroplasty. The indications and outcomes of reoperations following PIP arthroplasty have been recently reported by Pritsch and Rizzo [14]. Component revision can be very challenging to the surgeon as they have to limit bone destruction to maintain finger length and implant stability as well as balance tenuous soft tissues to maintain a functional joint. Thirteen fingers in their series were treated for swan neck deformity with six patients requiring subsequent revisions for correction. This data illustrates the unpredictability of revision surgery for swan neck deformity and supports the utility of a procedure like an FDS hemitenodesis. In this current series, one digit underwent revision arthroplasty.

Another option for these patients is a PIP joint arthrodesis. An arthrodesis is not a benign surgical option with a recent publication noting only 8 of 13 joints that achieved union at an average of 5.8 months [10]. Patient function and satisfaction may also be limited with a fusion. The surgically treated arthrodesis hands reported an average MHOQ score of 56.6, while the reported patients in our series had an average score of 68 on the operative hand.

A significant secondary finding in our study was the retained joint motion after hemitenodesis. Specifically, with average 30-month follow-up, patients had an average arc of motion of 39° without the use of a formal therapy protocol. All patients were allowed to advance their range of motion as tolerated after the initial 4 to 6 weeks of immobilization. The authors believe the retained motion without a burdensome therapy protocol associated with this procedure is of significant benefit to the patient.

Of note, 11 of the 14 fingers requiring surgical intervention for swan neck deformities had a primary longitudinal tendon splitting dorsal approach. The clinical impact of this finding is limited based on our study design, but the authors do believe that our findings suggest that the approach and subsequent closure may influence the development of this deformity. We therefore suggest taking care to not over tension the extensor mechanism closure.

The patient satisfaction survey and MHOQ data was limited by only 58 % patient participation. Of the small subset of patients that did complete the survey six of seven reported pain of three or less on a ten-point scale. Only two of the seven respondents stated that they were dissatisfied with the procedure. Both of these patients suffered an initial work-related traumatic injury resulting in their PIP arthroplasty. There was an average difference of ten points between the operative and non-operative hand using the Michigan Hand Outcomes Questionnaire. Limited information can be extrapolated from this data in such a small subset of the series. The average operative and non-operative scores were higher than those recently reported in patients undergoing PIP arthrodesis due to joint failure [10].

The authors acknowledge shortcomings with this retrospective study design with no control group. We are therefore limited in the data we can review and present to the reader. The follow-up for several of the patients was brief and we had a poor response to the questionnaires despite attempts to reach patients by mail and phone. The decision to perform a separate dorsal exposure and V-Y lengthening was determined on a case-by-case basis and offers bias into the analysis.

The presentation of a swan neck deformity after PIP arthroplasty can be a frustrating problem for patients and challenging treatment dilemma for hand surgeons. A soft-tissue arthrodesis has the benefit of being a simpler procedure than revision arthroplasty or formal bony arthrodesis. Our patients had the benefit of retaining some PIP motion, while maintaining the option for more invasive surgical possibilities down the road. Based on the low revision rate, as well as the favorable pain and patient satisfaction scores we believe this technique is a safe and effective treatment option for patients with swan neck deformities following unconstrained PIP arthroplasty.

Statement of Human and Animal Rights All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2008 (5). Informed consent was obtained from all patients submitting outcomes surveys for being included in the study.

Conflicts of Interest JF and MR have no conflicts of interest in relationship to the above data and manuscript.

Statement of Informed Consent No patient personal identifying information is enclosed. A written consent was signed prior to inclusion of the questionnaire data.

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