

Non-conventional tendon advancement for injuries in Verdan zones I and II. A new surgical technique

Alberto L. Garay, Carlos E. Martínez, Juan M. Patiño, Germán Tonetto, Francisco López Bustos

Upper Limb Department, Instituto Dupuytren (Buenos Aires, Argentina)

ABSTRACT

Objective: To report a new surgical technique and the comparative clinical outcomes in patients with primary tenorrhaphy rupture or chronic flexor digitorum profundus (FDP) injuries in Verdan zones I and II, treated with non-conventional tendon advancement. **Materials and Methods:** The study population consisted of 13 patients over 18 years (averaging 29 years) who had had injuries in Verdan zones I and II and at least a 36-month follow-up. Patients were divided into two groups according to injury type (7 cases of primary tenorrhaphy rupture and 6 cases of chronic FDP injuries) and surgical technique (Z-plasty lengthening plus end-to-end suture or lateral suture to an adjacent undamaged FDP tendon at zone-V level, respectively). The results were evaluated according to Strickland's scoring system. **Results:** The average follow-up was 51 months. Time period between injury and surgery averaged 11.7 weeks (range, 2-24 weeks). Strickland scoring system results: excellent in 8 patients, good in 4 patients, and poor in 1 patient. Study average tendon advancement was 20.5mm. **Conclusions:** Non-conventional tendon advancement for primary tenorrhaphy ruptures or chronic FDP injuries in Verdan zones I and II proved to be a reproducible and effective treatment.

Key words: Tendon; flexor; lengthening; Z-plasty.

Level of Evidence: III

Avance tendinoso no convencional para lesiones en las zonas I y II de Verdan. Nueva técnica quirúrgica

RESUMEN

Objetivo: Presentar una nueva técnica quirúrgica y los resultados clínicos comparativos de pacientes con roturas de tenorrafia primaria o lesiones crónicas del flexor profundo en las zonas I y II de Verdan, tratados con avance tendinoso no convencional. **Materiales y Métodos:** Se incluyó a pacientes >18 años, con antecedente de lesiones en las zonas I y II de Verdan y un seguimiento mínimo de 36 meses. La serie estaba formada por 13 pacientes (edad promedio 29 años) que fueron divididos en dos grupos según el tipo de lesión (7 con roturas de tenorrafia primaria y 6 con lesiones crónicas del flexor profundo) y la técnica quirúrgica utilizada (alargamiento en Z más sutura término-terminal y sutura lateral del tendón alargado a un flexor vecino indemne en la zona V, respectivamente). Se empleó la Clasificación de Strickland para la evaluación. **Resultados:** El seguimiento promedio fue de 51 meses. El intervalo promedio entre la lesión y la cirugía fue de 11.7 semanas. Según la Clasificación de Strickland, 8 pacientes tuvieron resultados excelentes; 4, buenos y uno, pobre. El avance tendinoso promedio fue de 20,5 mm en ambos grupos. **Conclusiones:** El avance tendinoso no convencional para lesiones en las zonas I y II de Verdan, sea en roturas de tenorrafia primaria o lesiones crónicas del flexor profundo, resultó un tratamiento reproducible y eficaz.

Palabras clave: Tendón flexor; alargamiento; zetaplastia.

Nivel de Evidencia: III

INTRODUCTION

Hand flexor tendon injuries are a prevalent presentation. When diagnosed acutely, literature advocates primary repair to achieve good final outcomes. However, in a setting where an early primary suture is not an option or a primary tenorrhaphy ruptures, tendon grafting is the treatment of choice.

Recibido el 30-7-2020. Aceptado luego de la evaluación el 2-8-2020 • ALBERTO L. GARAY, MD • albertogaray146@hotmail.com  <https://orcid.org/0000-0001-6371-0884>

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The main complications associated with primary or secondary suturing are adhesions and ruptures as well as the inherent complications associated with tendon grafts (whether forearm or lower extremity grafting, complications have been widely reported); it also should be bear in mind that the greater the number of surgeries, the greater the residual limitation.^{1,3}

In searching for alternatives for the conventional treatments, studies in the 1950s and 1980s reported encouraging results on the repair of rupture of flexor pollicis longus by lengthening at the Verdan zone-V level.^{4,5}

Le Viet performed FDP Z-plasties in cases of proximal stump retraction to achieve a primary suture.⁶

More recently, this non-conventional tendon lengthening procedure was used in the treatment of patients with triphalangeal FDP avulsion injuries (jersey finger).⁷

The purpose of this study is to report a new surgical technique and the comparative clinical outcomes in patients with primary tenorrhaphy rupture or chronic flexor digitorum profundus injuries in Verdan zones I and II, treated with non-conventional tendon advancement.

MATERIALS AND METHODS

We conducted a retrospective study on patients treated between December 2012 and March 2018. Inclusion criteria: patients over 18 years; primary tenorrhaphy rupture or chronic FDP injuries in Verdan zones I and II of triphalangeal fingers; with or without associated digital nerve lesion; and a 36-month minimum follow-up. All patients who failed to meet the inclusion criteria or had soft tissue defects, fractures or infections were excluded.

After exclusion, the series population was composed of 13 patients (9 males and 4 females) aged on average 29 years (range 20-49). The injury was to the dominant hand in 85% of cases (11 out of 13). Finger distribution: little finger, 6 cases; index finger, 3 cases; and middle and ring fingers, 2 cases each. Neurorrhaphy of collaterally damaged nerves was performed in 4 cases (30%). This procedure resulted in longer rehabilitation periods.

Surgeries were performed by two hand surgeons, under general or brachial plexus anesthesia, in a single surgical time as there were no recorded adhesions associated with the stump nor need for pulley reconstruction.

Study population was divided into two groups according to injury type and surgical technique.

Group A: primary tenorrhaphy rupture patients (7 cases) The surgical technique was a Z-plasty of the injured tendon proximal end at zone-V level, which procures tendon lengthening. This approach allows for reaching Verdan zones I and II at the distal end, where the end-to-end suture is performed (Figure 1). Tendon advancement is achieved through the pulleys of the injured tendon. The proximal end may be sutured to the distal end or be inserted into the third phalanx using the pull-out technique.

Group B: patients with previously non-treated chronic FDP injuries (6 cases) In the event of considerable tendon shortening in the proximal end which would prevent the end-to-end suture, we suggest performing the Z-plasty at the proximal end, advancing, suturing distally end-to-end, and suturing to an adjacent undamaged FDP tendon at zone-V level with continuous suture (from distal to proximal) (Figure 2). We suggest suturing at zone-V level because of that level has the lower reported adhesion rate.

Postoperative care

After surgery, both group patients were treated with immobilization using plaster casts extending above the elbow to protect the sutures, for 4 weeks. Rehabilitation exercises were instituted after cast removal and progressive load was incorporated to the hand 8 weeks after surgery.

Goniometric evaluations based on the Strickland scoring system were used to objectively assess outcomes, recording the total active range of motion (TAM), which was defined as the active flexion of the metacarpophalangeal (MCP), proximal interphalangeal (PIP) and distal interphalangeal (DIP) joints minus the extension deficits in these joints.⁸ Results were graded into four categories: 150°, excellent; 125° to 149°, good; 90° to 124°, fair; <90°, poor.

Statistical analysis of the tendon lengthening outcomes for each group was performed using IBM SPSS Statistics 19.0. The analysis was performed using nonparametric statistics. Values were considered to be statistically significant at $P < 0.05$.

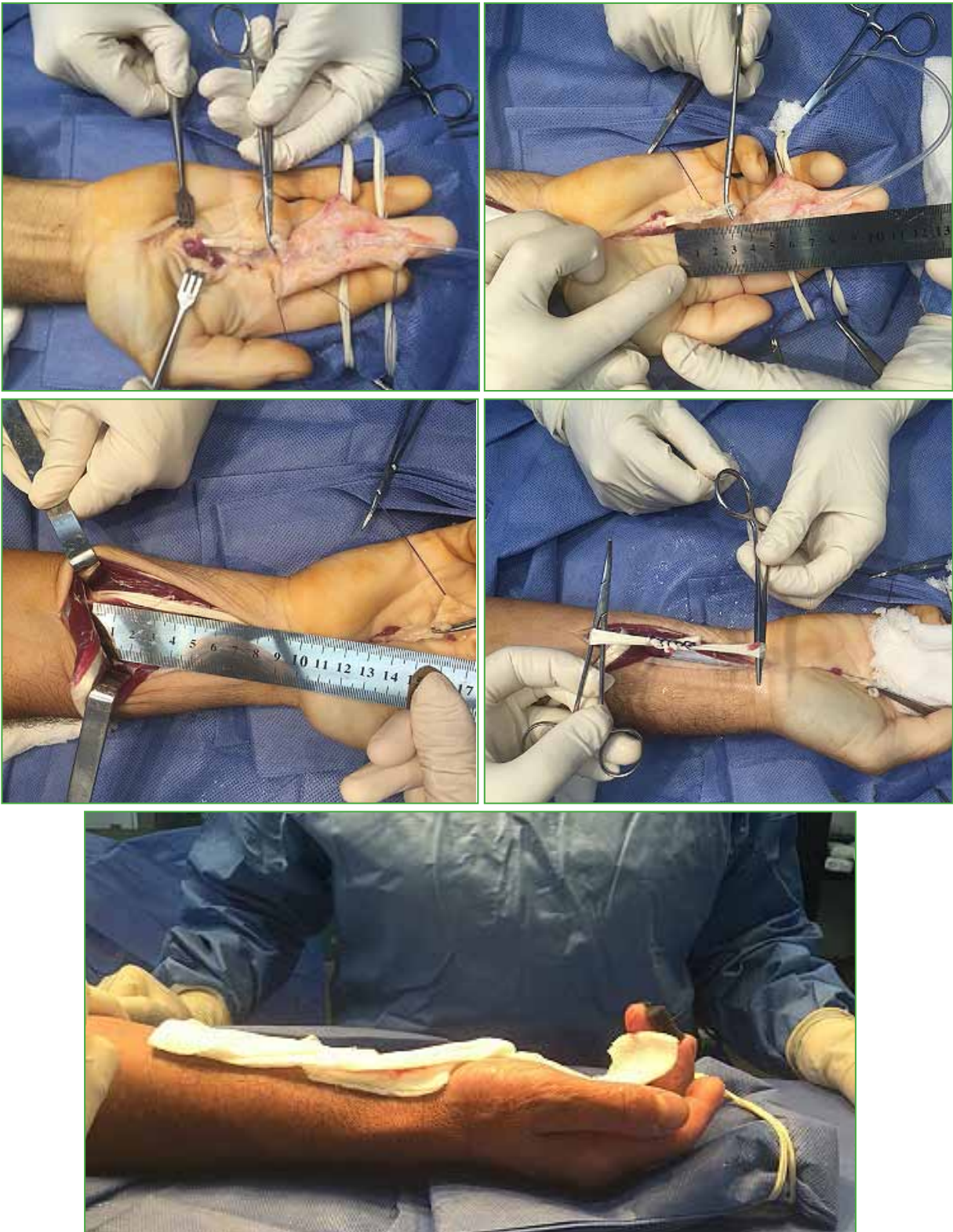


Figure 1. Intraoperative sequence of the non-conventional tendon advancement technique for primary tenorrhaphy ruptures.

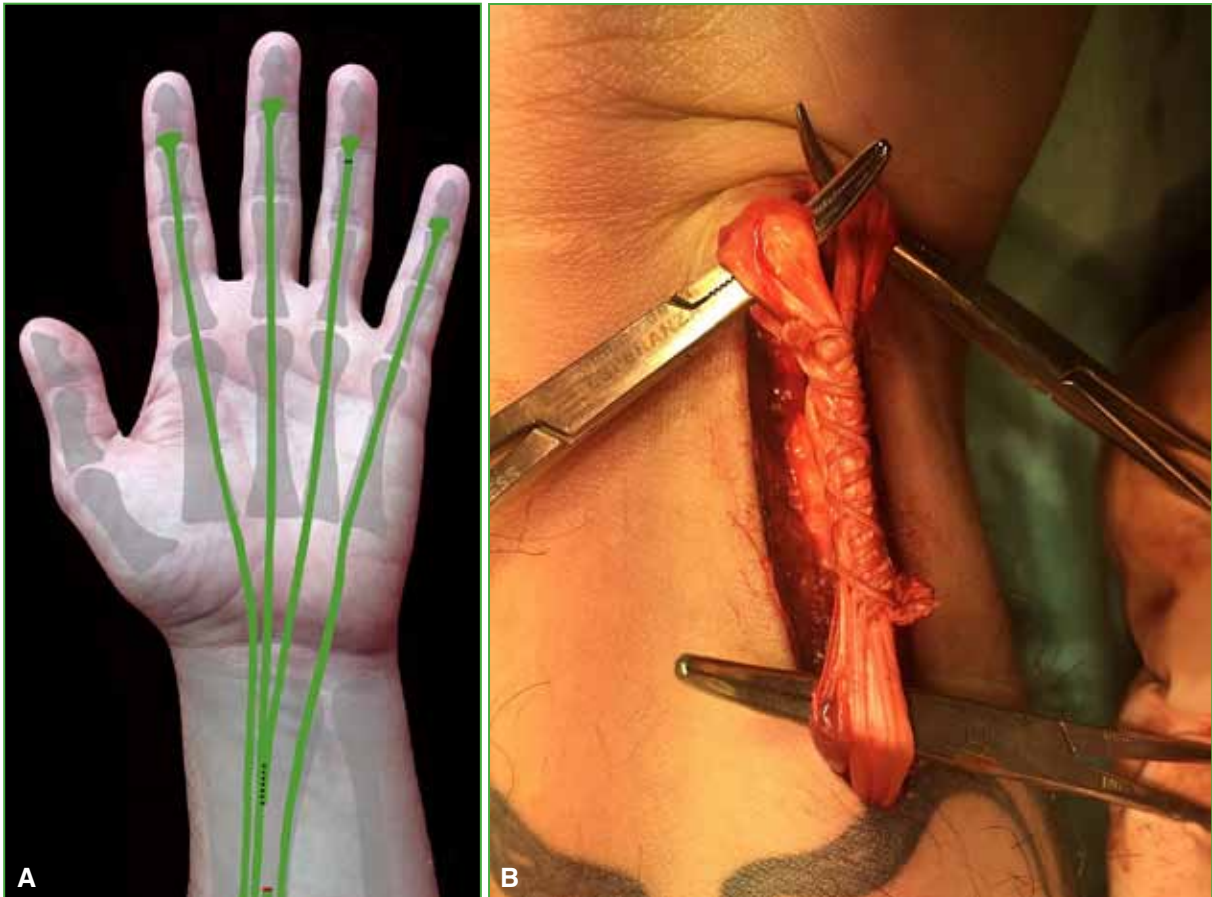


Figure 2. (A) Layout of the tenodesis of the retracted flexor tendon to the adjacent undamaged tendon. (B) Intraoperative image of lengthening suture used in chronic flexor digitorum profundus injuries.

RESULTS

The average follow-up was 51 months (range, 41-62). Time period between injury and surgery averaged 11.7 weeks (range, 2-24 weeks). Group A (7 patients) Strickland scores: 5 patients with excellent TAM, 1 with good TAM, and 1 with fair TAM. Group B (6 patients) Strickland scores: 3 patients with excellent TAM, and 3 with good TAM. [Tables 1 and 2](#) show the demographics, average follow-up, and Strickland scores of both groups.

Study average tendon advancement was 20.5mm (range, 12-33mm). Group A had an average advancement of 18mm and Group B of 23.5mm. This difference was statistically significant ($P=0.029$). [Table 3](#) shows the statistical data. There were no complications nor reoperations in either group.

DISCUSSION

FDP tendon reconstruction is indicated in cases of primary repair failure, delayed diagnosis with proximal stump retraction, and complex trauma with integument defect. This study compares the outcomes of two patient series undergoing two non-conventional tendon advancement for injuries in Verdan zones I and II for triphalangeal fingers. Both techniques provided good TAM values at last follow-up despite there being different settings.

Reconstruction prognosis is dependent on treatment delay, tendon retraction level, tendon blood supply, surrounding soft tissue conditions, absence of flexor digitorum superficialis injury, and surgeon's expertise.

Las opciones quirúrgicas clásicas incluyen avance del tendón, injertos en uno o dos procedimientos, transferencias de tendones y prótesis silásticas. Otras cirugías de rescate muy utilizadas son artrodesis, capsulodesis y tenodesis.

Table 1. Patient series treated for primary tenorrhaphy ruptures (Group A)

Case	Sex	Age (years)	Etiology	Finger, side dominance	Technique	Delay injury-surgery (weeks)	Follow-up period (months)	Advancement (mm)	Strickland's scoring system
1	M	25	Primary suturing failure	Fifth, right, dominant	Z-plasty	16	59	20	Excellent
2	M	23	Primary suturing failure	Fifth, left, dominant	Z-plasty	12	59	12	Excellent
3	M	25	Primary suturing failure	Second, right, dominant	Z-plasty	6	51	15	Fair
4	F	49	Primary suturing failure	Second, right, dominant	Z-plasty	2	57	15	Excellent
5	F	34	Primary suturing failure	Fifth, right, dominant	Z-plasty	24	50	20	Good
6	M	35	Primary suturing failure	Fourth, left	Z-plasty	5	54	30	Excellent
7	M	36	Primary suturing failure	Fifth, right, dominant	Z-plasty	20	49	22	Excellent

F = female; M = male.

Table 2. Patient series treated for chronic flexor digitorum profundus injuries (Group B)

Case	Sex	Age (years)	Etiology	Finger, side dominance	Technique	Delay injury-surgery (weeks)	Follow-up period (months)	Advancement (mm)	Strickland's scoring system
1	F	24	Chronic injury	Third, right, dominant	Intertendinous connection (fourth)	16	62	32	Excellent
2	M	22	Chronic injury	Fifth, right, dominant	Intertendinous connection (fourth)	6	41	22	Good
3	F	27	Chronic injury	Third, right	Intertendinous connection (fourth)	6	52	18	Good
4	M	26	Chronic injury	Fifth, right, dominant	Intertendinous connection (fourth)	24	49	24	Excellent
5	M	36	Chronic injury	Fifth, right, dominant	Intertendinous connection (fourth)	20	49	22	Excellent
6	M	20	Chronic injury	Fourth, right, dominant	Intertendinous connection (third)	4	50	25	Good

F = female; M = male.

Table 3. Group's average tendon advancement

	Patient	Group A (mm)	Patient	Group B (mm)
	1	20	1	22
	2	12	2	30
	3	15	3	18
	4	32	4	24
	5	15	5	22
	6	20	6	25
	7	12		
Average		18		23.5

Standard surgical options include tendon advancement, one- or two-stage grating, tendon transfer, and silastic rod implantation. Other widely used salvage surgical procedures include arthrodesis, capsulodesis, and tenodesis.

According to our literature research, grafting in all its variations constitute the most commonly chosen procedure. However, there is no consensus on which tendon would provide the best graft. Parameters that affect selection include diameter, length, and resistance. The most commonly harvested tendons are the flexor palmaris brevis, extensor digiti minimi, extensor digiti indicis, and toe extensors.^{9,10,11} Allotransplantation has also been proposed.¹²

Guimberteau *et al.* published a 71-case series where they propose the use of vascularized flexor tendons and report encouraging outcomes, although their follow-up period was limited.¹³

Likewise, the implantation of synthetic materials has been reported as an element in the treatment of flexor tendon injuries, provided they are well tolerated.^{13,16}

Sita-Alb and Durand proposed zone 1 and 2 flexor tendon reconstruction by transfer of half of the flexor superficialis tendon adjacent to the injured FDP tendon.¹⁷

The literature on forearm tendon lengthening includes some reports.⁶ Chanel *et al.* evaluated the FDP tendon advancement when performing a Z-plasty for the treatment of FDP tendon avulsion injuries (jersey finger).⁷ They reported FDP advancement limitations associated with the lumbrical muscles and synovial adhesions. They reported no limitation for the index finger. Although this technique was suggested for the treatment of this last condition, Z-plasty potential flexor tendon weakening and adhesion rate increase should be considered.

Both of these procedures warrant a meticulous technique and extensive expertise in flexor tendon repair.

The strengths of this study technique include: to result in a less complex surgical procedure, to avoid tendon grafting and its lower associated morbidity, to reduce surgical time, and to allow for one- or two-stage procedures (as required by the surgeon in cases of adhesions or pulley reconstruction necessity). These advantages may carry more weight in cases where more than two fingers require repair. Based on the tendon blood supply preservation and the similarity of the stumps anatomic diameters, we state that the tendon advancement achieved through the use of the pulleys bears no risk.

The limitations of this study include: its retrospective design, a limited study population, and the heterogeneity in the studied injuries (primary tenorrhaphy ruptures or untreated FDP injuries), which constituted potential biases when interpreting the results.

CONCLUSIONS

The non-conventional tendon advancement technique for primary tenorrhaphy ruptures or chronic FDP injuries in Verdan zones I and II for triphalangeal fingers proved to be a reproducible and effective treatment.

Conflict of interests: Authors claim they do not have any conflict of interest.

C. E. Martínez ORCID: <http://orcid.org/0000-0002-6031-0532>
 J. M. Patiño ORCID ID: <http://orcid.org/0000-0002-9036-0442>

G. Tonetto ORCID: <https://orcid.org/0000-0002-1740-3792>
 F. López Bustos ORCID: <http://orcid.org/0000-0002-2504-2026>

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