The Role of Dynamic Ultrasound in the Immediate Conservative Treatment of Volar Plate Injuries of the PIP Joint: A Series of 78 Patients

Le rôle de l'échographie dynamique pour le traitement prudent et immédiat des lésions de la plaque palmaire de l'articulation interphalangienne proximale : une série de 78 patients

Franck Marie Leclère, MD, PhD¹, Lukas Mathys, MD¹, Bettina Juon, MD¹, and Esther Vögelin, MD, PhD¹

Plastic Surgery
2017, Vol. 25(3) 151-156
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sagepub.com/journalsPermissions.nav
DOI: 10.1177/2292550317716122
journals.sagepub.com/home/psg

Abstract

Introduction: The management of volar plate avulsion fractures in the context of a stable joint and a bony fragment of less than 30% has traditionally been conservative. This study was performed to assess volar plate healing with high-resolution ultrasound in order to provide early full mobilization. **Material and Methods:** Between January 2012 and December 2013, 78 patients with volar plate injuries of the proximal interphalangeal (PIP) joints (42 distortions and 36 dislocations) were treated conservatively in our department for volar plate avulsion fracture associated with stable joint and bony fragment inferior to 30% of the intra-articular surface assessed both by radiography and ultrasound. Conservative treatment included extension stop splinting for the first 2 weeks and Coban bandage until 6 weeks postinjury. However, it may be possible to modify the duration of extension stop splinting based on clinical and ultrasound findings (with no additional X-ray) performed every 2 weeks for the first 3 months and then at 4 months postinjury. Only patients with residual contracture at the 4-month assessment had prolonged follow-up in order to ensure adequate dynamic splint therapy. **Results:** The amount of soft tissue oedema and the mobility of the volar plate were factors used to determine return to full mobilization. Mean extension-stop-splint wear was 16 ± 2 days. During the first 2 follow-up assessments, 4 patients were excluded from the study because of the instability of the PIP joint. One patient required refixation of a large fragment of 30%, 2 patients required superficial flexor tendon (FDS) tenodesis of the unstable volar plate in hyper-extension and 1 other patient required arthrodesis of the PIP joint. In 51 patients, the postoperative follow-up was free of complications at 4 months. In 18 patients, flexion contracture of 20° (range 11° - 40°) and oedema during follow-up required dynamic extension splints for 3 to 5 months. After this time, 5 patients had a residual contracture of 10° to 15° . **Conclusion:** Avulsion fractures of the volar plate at the PIP joint are common. In general, they have a good outcome using the conservative treatment with extension block splints. Flexion contracture is a common complication and may be reduced by immediate splints in full extension at night and Coban bandage during the day. High-resolution sonography is a convenient tool to evaluate palmar plate stability, to assess reduction of oedema, and thus to guide safe return to full range of movement.

Résumé

Introduction : La prise en charge des avulsions de la plaque palmaire lorsque l'articulation est stable et que le fragment osseux est inférieur à 30 % est habituellement conservative. Cette étude visait à évaluer la cicatrisation de la plaque palmaire à l'aide de l'échographie à haute résolution afin de favoriser un retour rapide à une mobilisation complète. **Matériel et méthodes :** Entre

¹ Department of Hand Surgery, INSELSPIITAL Bern, University of Bern, Bern, Switzerland

Corresponding Author:

Franck Marie Leclère, Department of Hand Surgery, INSELSPIITAL Bern, University of Bern, Freiburgstrasse, 3008 Bern, Switzerland.
Email: franckleclere@yahoo.fr

janvier 2012 et décembre 2013, 78 patients ayant des lésions de la plaque palmaire des articulations interphalangiennes proximales (IPP) (42 distorsions, 36 dislocations) associées à une articulation stable et à un fragment osseux inférieur à 30 % de la surface articulaire à la radiographie ont été traités de manière conservatrice et suivis par échographie. Le traitement incluait une attelle extension-stop pendant les deux premières semaines, puis un bandage CobanMD pendant les quatre semaines suivantes. Il était cependant possible d'adapter la durée du port de l'attelle en fonction des données cliniques et de l'échographie (sans radiographie) réalisée toutes les 2 semaines jusqu'à 3 mois, puis le quatrième mois suivant la lésion. Seuls les patients présentant une contracture résiduelle au bout de quatre mois étaient soumis à un suivi prolongé incluant une attelle dynamique. **Résultats :** L'ampleur de l'œdème des tissus mous et la mobilité de la plaque palmaire faisaient partie des facteurs utilisés pour déterminer le retour à une mobilisation complète. Le port moyen de l'attelle extension-stop était de 16 ± 2 jours. Lors des deux premières évaluations de suivi, quatre patients furent exclus de l'étude en raison de l'instabilité de l'articulation IPP : Pour un patient, un fragment de 30% a nécessité une refixation, pour deux patients, une ténodèse du tendon fléchisseur superficiel (TFS) a permis de stabiliser l'articulation instable en hyperextension et pour le dernier patient, une arthrodèse de l'IPP fut réalisée. Chez 51 patients, la guérison était complète après 4 mois. Chez 18 patients, une contracture résiduelle de 20° de flexion (11° à 40°) a exigé le port d'une attelle dynamique d'extension pendant une durée complémentaire de 3 à 5 mois. Après cette période, cinq patients présentaient une contracture résiduelle de 10° à 15°. **Conclusion :** Les avulsions de la plaque palmaire de l'articulation IPP sont des lésions courantes. Habituellement, un traitement conservateur à l'aide d'une attelle extension-stop permet leur guérison rapide. L'échographie à haute résolution quantifie la réduction de l'œdème et la guérison de la plaque palmaire, et par là permet de limiter le port de cette attelle extension-stop. La contracture résiduelle en flexion est une complication courante qui peut être traitée par attelle dynamique.

Keywords

volar plate, conservative treatment, PIP joint, hand surgery

Introduction

Injuries to the proximal interphalangeal (PIP) joint are routinely seen in a trauma centre. The stability of the PIP joint is provided by different structures¹⁻⁵: The volar plate (VP), first described by Fick in 1904, provides the stability of the PIP joint in the anterior–posterior plane; the collateral and accessory collateral ligaments reinforce the capsule laterally. The distal extremity of the VP is strongly attached to the periosteum of the middle phalanx in the anterior–posterior plane. Its 2 proximal lateral fibrous bundles, termed checkrein ligaments, attach to the capsule and thus have more intrinsic “give.” Consequently, in case of forced hyperextension, which is most often the mechanism of trauma, avulsion of the VP usually occurs at the distal attachment.

Although avulsion fragments involving greater than 30% of the articular surface are considered unstable and should be referred for surgical intervention, management of VP injury in the context of a stable joint and a bony fragment less than 30% of the intra-articular surface has traditionally been conservative. However, there is debate about whether conservative treatment should involve early mobilization or a period of immobilization in a cast.⁶⁻⁸ According to the work of Saito et al^{9,10} and our own experience, it is possible to assess the VP with dynamic sonography: the biomechanics of the VP are mainly composed of sliding, elevating, and rolling in the recess.^{9,10}

In order to provide safe and early full mobilization, we used high-resolution ultrasound to assess VP healing after palmar plate avulsion fracture. We focus on the immediate follow-up, possible complications, and discuss our guidelines compared to the current literature.

Material and Methods

Patients

This retrospective clinical study was conducted in accordance with the ethical guidelines of the INSELSPITAL Bern. Study inclusion criteria were patients with VP injury, and a bony fragment inferior to 30% assessed both by plain radiograph and ultrasound at the initial visit. Inclusion criteria were patients treated at the university hospital between January 2012 and December 2013. Exclusion criteria were cases with previous injuries of the involved joint, PIP joint with complete instability, and bony fragment greater than 30%. Seventy-eight patients, 31 women and 47 men, met the study criteria. The mean age of patients was 34.3 years (range 16–67 years).

Etiologies

Etiologies of the VP injuries were hyperextension trauma of the PIP joint, that is, distortions in 42 patients and dislocation in the remaining 36 patients. The affected finger was the index finger in 8 patients, the middle finger in 28 patients, the ring finger in 29 patients, and the little finger in 13 patients.

Conservative Treatment and the Use of Ultrasonography

Standard conservative treatment included extension stop splint for the first 2 weeks and Coban bandage until 6 weeks post-injury. The fact is that stability of a swollen, painful joint is sometimes initially not easy to assess especially in an emergency department. In other words, it is not always easy to

Figure 1. Standard conservative treatment included extension stop splint for the first 2 weeks (A) and Coban bandage until at least 6 weeks postinjury, depending on soft tissue oedema (B).

Figure 2. Patients with volar plate injury, stable proximal interphalangeal (PIP) joint, and a typical bony fragment less than 30%; (A) anteroposterior view; (B) lateral view.

define 0° stability or extension deficit stability during the first clinical examination and we err on the side of caution: In case of possible PIP joint hyperextension or oedema which could be masking instability, the extension splint is used until initial scarring occurs.

Extension stop splint was always in 20° of flexion (Figure 1). This type of splint would seem a good compromise, limiting full extension but allowing flexion of the joint, thereby protecting against hyperextension instability and preventing contracture or stiffness associated with flexion immobilization. Additional strapping to the corresponding neighbour digit depended on the stability of the collateral ligaments. Clinical and ultrasound assessments were performed every 2 weeks for the first 3 months and then at 4 months postinjury. High-resolution ultrasound (iU-22 system, transducer 17.5 MHz, Philips Medical Systems, Andover, MA, USA) with no additional X-ray of the PIP joint was used to assess the volar chip fragmentation, the localization, the step-off and gap of the VP

Figure 3. Same patient as in Figure 2: typical bony fragment less than 30% assessed by ultrasound (yellow arrow). Spatial relationship between the fragment and the middle phalanx (space between the 2 marks).

Figure 4. High-resolution sonography of the proximal interphalangeal (PIP) joint of the little finger (right side): (A) at the time of trauma, (B) 6 weeks postinjury showing the reduction of soft tissue oedema, and (C) after 3 months showing the bone consolidation (D) contralateral side (left side).

fragments on the day of injury as well as the stability of the palmar plate, the amount of oedema, and the collateral ligament stability. In due course, the stability of the VP and the collateral ligaments, the reduction of soft tissue oedema, the tendon gliding, and the range of movement was used to determine return to full mobilization. In other words, the duration of extension-stop-splint wear could be modified depending on the ultrasound findings. Patients with residual contracture at the 4-month assessment were followed up for longer in order to ensure adequate therapy with a dynamic splint. In cases of complete healing of the VP, full stability of the PIP

joint, and lack of flexion contracture, the patients were discharged at 4 months.

Measured Parameters

In each case, extension-stop-splint wear, range of motion, and complications were carefully assessed. Data are presented as mean $\pm$ standard error of the mean.

Results

In this retrospective study, 78 patients with VP injuries of the PIP joint (42 distortions and 36 dislocations) were treated conservatively in our department for palmar plate injury associated with a bony fragment inferior to 30% of the intra-articular surface on initial X-ray and ultrasound (Figures 2 and 3).

Initial Assessment of Joint Stability

Sonographically, the initial palmar bony avulsion could be precisely localized. In 32 of the 78 patients, the position of the avulsed chip fragments did not correlate exactly between the repeated ultrasonographies and the initial X-rays. Sonography allowed more precise localization: There was 1 to 3 mm gap of the avulsed fragment, but sonography revealed continuity to the palmar plate.

Sonographic Assessment of the Joint During the First 4 Months

During the first 2 assessments, 4 patients were excluded from the studies because of the instability in the PIP joint. One patient required refixation of a large palmar plate fragment of 30%, 2 patients required superficial flexor tendon (FDS) tenodesis of the unstable VP in hyperextension, and 1 other patient needed arthrodesis of the PIP joint. Seventy-four patients were treated conservatively. To avoid hyperextension lag, the mean extension-stop-splint wear was 16 ± 2 days. Reduction of soft tissue oedema and the return to elevation of the VP were used as the criteria to switch treatment from mobilization under extension stop splint to full mobilization (Figure 4). In general, sonography could predict stiffness of the digit from the amount of oedema present. The more oedema was present sonographically, the less mobile was the palmar plate when examining the arc of flexion and extension between 30° . Clinically, these digits were more swollen, and there was good correlation with sonography. In all but the 4 excluded patients, there was no increasing gap formation.

Four-Month Follow-up Assessment

Five patients were lost to follow-up. In 51 patients, the postoperative follow-up was free of complications, and these patients were not followed up beyond 4 months. In 18 patients, flexion contracture of 20° (range 11° - 40°) and oedema during follow-up required dynamic and/or static extension splints for

3 to 5 months. During this follow-up period, 5 patients had a residual flexion contracture of 10° - 15° .

Discussion

In this retrospective study, 74 of the 78 patients included with VP injuries of the PIP joints were treated conservatively and assessed during follow-up by dynamic ultrasound. The mean extension-stop-splint wear was 16 ± 2 days. Major complications were found in the 4 excluded patients: 1 required palmar plate refixation, 2 patients needed FDS tenodesis to avoid PIP joint hyperextension. One patient with chronic dislocation of PIP joint required arthrodesis. Five patients were lost to follow-up. In 51 patients, the postoperative follow-up was free of complications. These patients were not followed up beyond 4 months. In 18 patients, flexion contracture of 20° (range 11° - 40°) and oedema during follow-up required dynamic extension splints for 3 to 5 months. After this time, 5 patients had a remaining flexion contracture of 10° - 15° .

Despite a few successful operative reports,^{11,12} the management of VP injury in the context of a stable joint and a bony fragment inferior to 30% of the intra-articular surface has traditionally been conservative. However, the conservative management is contentious. It remains split into immediate mobilization and mobilization after a period of immobilization in a cast. In 1988, Incavo et al¹³ reported their experience with joint immobilization in full extension for 7 to 10 days using aluminium or orthoplastic splints, followed by a 6-week period of buddy strapping. Good functional results were reported without cases of hyperextension instability in their series of 45 patients. Interestingly, there was 1 case of flexion contracture. However, this study was limited by an alarming loss to follow-up of more than 50% of the treated patients. Around the same time, Phair et al¹⁴ presented their experience of 74 patients with VP injury associated with avulsion fractures of the PIP joint. Their series was divided into 2 groups treated by buddy strapping and active mobilization only or by immobilization with a dorsal splint in 30° of flexion. Despite excellent results found in both groups, the mobilizing buddy-strapped group showed earlier return to normal range of movement and a slightly better functional outcome (96.6% "excellent" outcome compared with 93% in the other group). Ten years later, Gaine and Beardsmore¹⁵ presented the results of a prospective series involving a cohort of 162 patients who had undergone immediate mobilization of VP avulsion fractures. The minimum follow-up was at least a year and 98% of them achieved good results. However, the patients' inclusion was confusing: Although some of the patients were referred by an outside source and were not seen initially at the clinic, there was no discussion of the initial treatment used prior to the study assessment. Reports from other specialist centres have confirmed that immobilization may not be necessary, provided that the injured joint is clinically stable.¹⁶⁻¹⁸ These teams advocated early mobilization, placing an emphasis on specialist physiotherapy.

In our study on 78 patients, early mobilization was the rule. However, extension was limited by the extension-stop-splint

worn in 20° of flexion. The fact is that joint stability in a swollen, painful joint is sometimes initially not easy to assess especially in an emergency department. In other words, it is not always easy to define 0° stability or extension deficit stability during the first clinical examination, and we prefer the risk of overtreatment to that of undertreatment. In case of possible PIP joint hyperextension or oedema that could hide an instability, the joint was treated as if they presented minor instability, and the extension splint was used until initial scarring occurs. This type of splint is a good compromise, limiting full extension but allowing flexion of the joint, thereby protecting against hyperextension instability and preventing contracture or stiffness associated with flexion immobilization. Moreover, with the use of the dynamic ultrasound evaluations, we have tried to adapt the treatment to each patient in order to return to full mobilization as soon as possible while avoiding the risk of instability or contracture. High-resolution ultrasound confirmed herein its numerous advantages: (1) It is a useful tool to assess the amount of soft tissue oedema and the localization of the bony fragment. (2) Moreover, it also gives a dynamic image of the VP and provides early information about stability: With the use of this dynamic tool, we observed a correlation between soft tissue oedema and stiffness of the palmar plate and range of movement of the digit. According to the work of Saito et al^{9,10} and our own experience, the biomechanics of the VP is mainly composed of sliding, elevating, and rolling in the recess.^{9,10} The elevating phase is crucial to function and must be scrutinized carefully in order to allow return to full mobilization. (3) Finally, the sonography machine is easily available in the consultation room. Instability could not be avoided by the extension splint in 4 cases, in 2 of which the palmar plate fixation was not thought to be a suitable option, and FDS tenodesis was performed. In the third patient, the palmar plate fragment was 30%, and refixation of the osseous fragment was performed. One patient with chronic luxation of PIP joint required arthrodesis. On the other hand, due to the extension block splint, despite stable initial VPs confirmed by ultrasonography, mild (10°-15°) to severe (40°) flexion contracture emerged as a problem in 18 patients. We have therefore since changed our practice with regard to application of an extension splint (Figure 5). In stable palmar plates, a night splint in full extension is applied, and during daytime, only taping is mandatory to treat oedema and swelling. Especially in patients with a lot of soft tissue oedema, compression bandages with Coban are recommended.

Despite the large number of patients in this study, methodological limitations remain. Firstly, this study was limited by its nature as a retrospective analysis. Nonetheless, all patient details were meticulously registered and continuously followed over 4 months until satisfactory mobilization was documented in the clinic's electronic database. Secondly, there was no control group. However, our reading of the literature would support a real shift from mobilization after a period in a cast to immediate mobilization. Finally, the follow-up period was limited, but hyperextension or flexion contracture as mentioned above occurred early. However, in contrast to the study of

Figure 5. Our decision tree in palmar plate avulsion with bony fragment <30%.

Povlsen and Singh,¹⁹ all patients presented with acute trauma: patients with old injuries were not included in the series.

Despite all these limitations, one could question why the use of ultrasound for the assessment of VP injury has taken so long to develop. Two arguments can largely explain this: firstly, the information provided by ultrasound is highly dependent on the user's skill. Regular ultrasound training and teaching in our department allows standard and homogeneous examination. In addition, the development of this technology is exponential, the latest devices now allow us to see structures with greater sensitivity and specificity than even in the previous decade.

Conclusion

Avulsion fractures of the VP at the PIP joint are common. In general, they have a good treatment outcome, although complications do occur. Treatment should aim to prevent complications, while maximizing functional outcome. High-resolution sonography is able to ensure quick and safe return to mobilization.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

References

- Freiberg A. Management of proximal interphalangeal joint injuries. *Can J Plast Surg*. 2007;15(4):199-203.
- Bowers WH, Wolf JW Jr, Nehil JL, Bittinger S. The proximal interphalangeal joint volar plate. I. An anatomical and biochemical study. *J Hand Surg Am*. 1980;5(1):79-88.
- Bowers WH, Hill C. The proximal interphalangeal joint volar plate. II. A clinical study of hyperextension injury. *J Hand Surg Am*. 1981;6(1):77-81.

4. Bowers WH. Sprains and joint injuries in the hand. *Hand Clin.* 1986;7(1):93-98.
5. Gad P. The anatomy of the volar part of the capsules of the finger joints. *J Bone Joint Surg.* 1967;49(2):362-367.
6. Body R, Ferguson CJ. Best evidence topic report. Early mobilisation for volar plate avulsion fractures. *Emerg Med J.* 2005;22(7):505-506.
7. Freiberg A, Pollard BA, Macdonald MR, Duncan MJ. Management of proximal interphalangeal joint injuries. *J Trauma.* 1999;46(3):523-528.
8. Blazar PE, Steinberg DR. Fractures of the proximal interphalangeal joint. *J Am Acad Orthop Surg.* 2000;8(6):383-390.
9. Saito S, Suzuki S, Suzuki Y. Biomechanical differences of the proximal interphalangeal joint volar plate during active and passive motion: a dynamic ultrasonographic study. *J Hand Surg Am.* 2012;37(7):1335-1341.
10. Saito S, Suzuki Y. Biomechanics of the volar plate of the proximal interphalangeal joint: a dynamic ultrasonographic study. *J Hand Surg Am.* 2011;36(2):265-271.
11. Lee S, Jung EY, Kim JY. Operative treatment for volar plate avulsion fractures of the fingers. *Arch Orthop Trauma Surg.* 133(10):1463-1467.
12. Komura S, Yokoi T, Nonomura H. Mini hook plate fixation for palmar fracture-dislocation of the proximal interphalangeal joint. *Arch Orthop Trauma Surg.* 2011;131(4):563-566.
13. Incavo SJ, Mogan JV, Hilfrank BC. Extension splinting of palmar plate avulsion injuries of the proximal interphalangeal joint. *J Hand Surg Am.* 1989;14(4):659-661.
14. Phair IC, Quinton DN, Allen MJ. The conservative management of volar avulsion fractures of the P.I.P. joint. *J Hand Surg Br.* 1989;14(2):168-170.
15. Gaine WJ, Beardsmore NF. Early active mobilisation of volar plate avulsion fractures. *Injury.* 1998;29(8):589-591.
16. Moutet F, Hasart P, Frere G. Value of immediate mobilization in proximal interphalangeal volar plate avulsions[in English, French]. *Ann Chir Main.* 1984;3(3):221-226.
17. Barton NJ. Fractures of the phalanges of the hand. *Hand.* 1984;1(1):1-10.
18. Benke G, Stableforth PG. Injuries of the proximal interphalangeal joints of the fingers. *Hand.* 1979;3:263-268.
19. Povlsen B, Singh R. Outcome of late presentation of injuries of the volar plate of the proximal interphalangeal joint. *J Plast Surg Hand Surg.* 2010;44(3):167-170.