Hand Surgeon Reporting of Tendon Rupture Following Distal Radius Volar Plating

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Abstract

Background: Volar plate fixation with locked screws has become the preferred treatment of displaced distal radius fractures that cannot be managed nonoperatively. This treatment, however, is not without complication. The purpose of this study was to determine what percentage of hand surgeons, over a 12-month period, have experienced a tendon complication when using volar plates for the treatment of distal radius fractures. **Methods:** A total of 3022 hand surgeons were e-mailed a link to an online questionnaire regarding their observation and treatment of tendon injuries associated with volar plating of distal radius fractures. Responses were reported using descriptive statistics. **Results:** Of the 596 (20%) respondents, 199 (33%) surgeons reported encountering at least one flexor tendon injury after distal radius volar plating over the past year of practice. The flexor pollicis longus was the most commonly reported tendon injury (254, 75%). Palmaris longus grafting (118, 37%) and tendon transfer (114, 36%) were the most often reported treatments following this complication. A total of 216 respondents (36%) also encountered 324 cases of extensor tendon rupture after volar plating of distal radius fractures, with tendon transfer (88%) being the preferred treatment option. **Conclusions:** Both flexor and extensor tendon ruptures can be seen after volar plating of distal radius fractures. Surgeons should be aware of these complications. Critical assessment of hardware position at the time of index procedure is recommended to avoid complications. Long-term studies are needed to standardize approaches to managing tendon rupture following volar plating of distal radius fractures.

Keywords: tendon rupture, volar locked plating, questionnaire, survey

Introduction

Distal radius fractures remain one of the most common orthopedic injuries, accounting for 8% to 17% of all extremity fractures.^{22,26} Although management ranges from conservative care to operative intervention, neither systematic reviews nor clinical practice guidelines have defined a single, uniformly superior approach.^{2,12} Surgeon factors, including membership to the American Society for Surgery of the Hand (ASSH), duration of practice, and training background have been shown to positively impact the rate at which patients receive treatment with internal fixation for this injury.⁸ The current trend in surgical stabilization is the use of a volar plate to internally fix unstable or displaced distal radius fracture patterns.^{19,25} Proponents of this method cite biomechanical benefits, procedural advantages, and potentially lower complication rates compared with dorsal plating options.³⁴

Despite the benefits offered with volar plating, a seemingly rare consequence of using this technique is irritation and subsequent rupture of the flexor pollicis longus (FPL)

and flexor digitorum profundus (FDP) tendon to the index finger. Depending on plate position and screw length, other tendons may be at risk as well. There are minimal studies evaluating tendon injuries after volar plate fixation for distal radius fractures.^{3,6,9}

Several authors have tried to identify patients at risk for tendon rupture after volar plating by describing radiographic parameters of plate position.^{4,29} Identification of the watershed line²⁵ and the Soong classification²⁹ are two of the more commonly used means of assessing plate position on the radius. Orbay and Touhami first described the watershed line as the distal most prominence of the pronator fossa on the volar radius. The authors suggested that plate placement distal to this zone may predispose the patient to

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tendon rupture. Indeed, tendon contact pressures have been shown to increase when plates are placed distal to this line.³² Soong developed a grading scale for volar plate position using a critical line drawn tangential to the most volar aspect of the distal radius volar rim, parallel to the radial shaft.²⁹ According to this system, grade 0 refers to implants located proximal to the volar rim and dorsal to the critical line. Grade 1 implants are volar to the critical line but proximal to the volar rim. Grade 2 plates are volar to the critical line and distal to the volar rim. A higher Soong grade is correlated with more prominent hardware with the potential for tendon complications. It is unknown how frequently these metrics are employed by hand surgeons today.

The purpose of this study was to determine via an online questionnaire what percentage of hand surgeons, over a 12-month period, have experienced a tendon complication when using volar plates for the treatment of distal radius fractures. From clinical experience, we hypothesized that tendon rupture after volar plating is more common than one might expect based on a review of the current literature.

Methods

We performed an online survey, approved by the institutional review board at our institution. After permission was granted by the ASSH administration, the senior author sent all members ($n = 3022$) an e-mail request. Within the electronic document was a link providing access to the survey (surveymonkey.com).

The survey contained 12 questions and asked the surgeons to recall experiences over the past 12 months of practice (see the appendix). A response was required for all questions. Demographic information of the surgeon, tendon complications, complication management, and evaluation of volar plate position was requested from the respondents. A description of the Soong classification was provided. The estimated completion time was 5 minutes. Consent for participation was obtained when respondents accessed a separate survey site page. All responses were confidential. To keep an accurate representation of the data, respondents were asked not to take the survey more than once or forward the link to other individuals. Internet Protocol (IP) address and completion time were recorded for every individual response. Information was collected for 8 weeks following the initial electronic request. One reminder message was sent at 4 weeks from the first request. The data were then collected and analyzed using descriptive statistics. The primary outcome measurement was quantity of reported flexor tendon ruptures, with the hypothesis that tendon rupture occurs more frequently than previously reported. A non-parametric Kruskal-Wallis test was used to determine whether there was any difference between tendon complication reporting and respondent duration of practice, using IBM SPSS software version 12.0 (Chicago, Illinois).

Results

In total, 596 members of the ASSH responded to the survey request, yielding a response rate of 20%. Demographic information was then queried on the basis of duration of practice (Figure 1). Of the respondents, the majority 334 (56%) were hand surgeons practicing for more than 15 years. An additional 83 respondents (14%) reported being in practice for 10 to 14 years. The remaining 179 (30%) surveyed individuals had been in practice for less than 10 years.

Utilization of various internal fixation plating techniques varied greatly. Approximately 96% (575) of surgeons reported treating at least one distal radius fracture with a volar plate within the past year. Conversely, only 51% (303) of those surveyed reported using one or more dorsal plates during the same time period.

Respondents estimated their respective case volume of volar plating of distal radius fractures over the past year of practice within a specific range (0, 1-9, 10-19, 20-50, or >50 cases). The total minimum number of cases reported was 11 028 and the maximum number of cases totaled at least 20 876. Specifically, 78 (13%) responders noted they managed 1 to 9 cases annually with volar locked plating, 142 (24%) managed 10 to 19 cases, 274 (46%) managed 20 to 49 cases, and 81 (14%) managed more than 50 cases annually.

Surgeons were questioned regarding their practice of plate removal. Less than 1% (4) of respondents reported routinely removing all volar distal radius plates. On the other end of the spectrum, less than 8% (45) reported never removing distal radius plates. A majority of the respondents, 92% (547), indicated that plate removal was considered when hardware was symptomatic and/or the plate was determined to be malpositioned.

According to our survey, at least 810 distal radius plates were removed over the study period for tendon irritation or tendon rupture. Surgeons were asked to reveal their assessment of hardware position during removal with respect to the watershed line²⁵ and according to the Soong classification.²⁹ In 20% of reported cases, plates were either not assessed or the surgeon was unable to recall the location of the plate with respect to the watershed line. Of the remaining cases of plate removal, the volar plate was positioned proximal, distal, and at the watershed line approximately 21% (170), 43% (347), and 16% (129) of the time, respectively. The Soong classification was not used by 204 (34%) responding surgeons. Of those who did report assessing plate position with this scheme, at the time of removal, plates were noted to be grade 0, 1, or 2, in 17%, 45%, and 39% of cases, respectively.

Both flexor and extensor tendon ruptures following volar plating of distal radius fractures were encountered. A total of 199 surgeons (33%) managed a total of 294 patients with

Figure 1. Respondent distribution to survey question 1: How many years have you been in practice?

flexor tendon rupture complications. In total, 338 flexor tendons were noted to be completely ruptured, with the most commonly injured tendon being the FPL in 254 (75%) cases. The second most commonly reported flexor tendon injury was the FDP tendon to the index finger in 61 (18%) cases. No significant difference was found between the number of reported tendon ruptures and the respondents' categorical years of clinical practice ($P = .078$; Table 1). The ratio of patients with tendon rupture (294) compared with the total estimated case volume of primary volar plating of distal radius fractures (11 028 to at least 20 876 cases) was between 1% and 2%.

The reported flexor tendon ruptures were managed with a total of 259 surgical procedures. Of the reported operative techniques, palmaris longus grafting was most often utilized 118 times (37%), followed by tendon transfer in 114

Table 1. Reported Flexor Tendon Ruptures Following Volar Plating of Distal Radius Fractures Stratified by Surgeon Duration of Practice.

Years in practice	0	1-4	5-9	10-14	15	Total
Reported patients	3	28	41	30	192	294
with flexor ruptures	1%	10%	14%	10%	65%	
Respondents	20	83	76	83	334	596
	3%	14%	13%	14%	56%	

cases (36%). Primary end-to-end repair, digital joint arthrodesis, FPL tenodesis, and alternative grafting options were also reported (Table 2).

A total of 324 patients experienced approximately 354 extensor tendon ruptures. The most commonly reported extensor tendon injury was the extensor pollicis longus

Table 2. Respondent Reporting of Flexor Tendon Repair Techniques Utilized in Managing a Distal Radius Volar Plate Complication.

	Total techniques (321)	%
End to end	42	13
FPL tenodesis	8	2
PL grafting	118	37
Tendon transfer	114	36
Digital joint arthrodesis	23	7
Other graft	16	5

Note. FPL, flexor pollicis longus; PL, palmaris longus.

Table 3. Respondent Reporting of Extensor Tendon Rupture Repair Techniques Utilized in Managing a Distal Radius Volar Plate Complication.

	Total procedures (359)	%
Primary repair	15	4
Grafting	27	8
Transfer	317	88

(EPL) in 259 cases (73%). Rupture of the extensor digitorum communis (EDC) to any digit and the extensor indicis proprius (EIP) was also found in approximately 65 (18%) and 30 (8%) cases, respectively. Tendon transfer was used most often in treatment of this complication 317 (88%) times (Table 3).

Closure practices varied among surgeons using the volar plate. A total of 323 (54%) surgeons reported always repairing the pronator quadratus (PQ), whereas 79 surgeons (13%) stated they never attempted this. The remaining 194 respondents (33%) took into account patient-specific and fracture-specific characteristics when deciding to repair PQ over the volar plate.

Discussion

Tendon rupture following dorsal plating of distal radius fractures is a well-documented complication.^{14,27} Surgeons have gravitated more recently to volar plating to minimize the previous tendon issues seen with dorsal plating.²⁴ Yu and colleagues demonstrated that the newer generation, lower profile dorsal plates, however, do not increase complication rates compared with volar plating in the same manner that traditional dorsal plates have.³⁵ Nevertheless, there appears to be a clear shift in surgeon preference for volar plating over dorsal approaches. In the current study, almost all respondents (96%) reported using volar plates, but just over half (51%) reporting using dorsal plates as sole fixation within the study time period. Over the past 2 decades, the frequency of use of volar locked plates has more than doubled.¹¹ As this trend continues, more data will

become available for long-term outcome and complication reporting.

Relatively few articles can be found reporting tendon injury after volar plating of the distal radius. One systematic review of the literature published in 2013 suggested that only 47 case reports were available in 21 studies.³ The often-quoted prevalence rate of up to 12% is derived from a series following only 50 total fractures demonstrating 6 late tendon ruptures after volar plating.¹⁰ The true prevalence of tendon rupture following volar plating remains unknown. Although only 33% of surgeons in the current study reported encountering tendon rupture over the past year of practice, the total number of reported flexor tendon ruptures (338) is more than the sum total of all previously reported tendon ruptures.³ Given this finding, it is possible that the true rate of flexor tendon rupture following volar plating of distal radius fractures differs from what has been previously described.

Time from the index procedure to tendon rupture after volar plating varies. Injuries have been reported from 3 months post procedure¹⁰ up to 10 years post implantation of a volar plate construct.²¹ Asadollahi and Keith systematically reviewed the literature and report that most flexor tendon ruptures following volar plating occur at an average of 9 months after the index procedure (range = 6-26).³ One explanation for late tendon ruptures is that FPL contact pressures have been shown to increase at 60° of wrist extension.³² It is thought that when rehabilitation restores motion beyond this measurement, flexor tendons become more at risk of rupture. The current survey did not assess time to tendon rupture, but rather reported on complications that were encountered within the past year of practice for the respondents.

The Soong classification offers an organized approach to assess the position of volar locked plates on the distal radius. It can be an important guide to screen for patients at risk of tendon injury following volar plating of distal radius fractures.²⁹ Surprisingly, less than two-thirds of the current survey respondents routinely used this method. The watershed line, however, was reported in approximately 80% of hardware removal cases. Although no clear consensus exists to define optimal plate placement, it may be beneficial for surgeons to utilize a standard routine when evaluating plate position throughout the perioperative encounter.

Mechanical irritation from the volar plate has been suggested to be an underlying source of local flexor tendon degeneration. Consequently, some authors advocate closure of the pronator to prevent direct tendon-plate contact.^{23,31} Opponents of pronator repair over volar plates, however, cite lack of usefulness in protecting tendons with a potentially tenuous repair.^{15,30,33} A majority of respondents (87%) indicated that they routinely or on a case-by-case basis consider repairing PQ during volar exposures, which correlates with previous studies.³⁰

A large number of extensor tendon ruptures were also noted after volar plating. Previous published series reported a 4.4% to 8.6% incidence of extensor tendon rupture following volar plating.^{1,36} One proposed mechanism for extensor tendon injury includes attritional damage secondary to screw penetration of the dorsal cortex. Maschke and colleagues proposed supination/pronation fluoroscopic imaging to appropriately assess screw position intraoperatively to avoid this complication.²⁰ It is important to note that even conservatively managed distal radius fractures might lead to extensor tendon rupture. Roth indicated that EPL rupture occurred in 5% of nondisplaced distal radius fractures managed nonoperatively.²⁸

There is no consensus regarding an optimal technique to manage tendon rupture following volar plating of the distal radius. Tendon transfer appears to be a reliable option, as it was reported to be used commonly to treat both flexor and extensor ruptures. This technique was used much more consistently in managing the extensor side of the distal radius (88% vs. 36%) compared with volar tendon complications. One reason to explain this finding is that there is good reproducibility of the EIP to EPL transfer. Lemmen et al demonstrated that the EIP is in phase, has sufficient caliber, and is expendable to treat EPL ruptures through transfer.¹⁷ Although the flexor tendon to the thumb was also the most commonly reported tendon ruptured on the flexor surface, there seems to be much less consensus on the management of FPL rupture as opposed to EPL rupture. In addition to tendon transfer, primary repair, interphalangeal arthrodesis, and tendon grafting were all techniques used to manage the complication of tendon rupture following volar plating of distal radius fractures.

Two-thirds (397) of the current survey respondents did not experience tendon rupture following volar plating. It is not known why there is a disparity in experience with this particular complication. No direct assessment was made between plate design and tendon rupture in this study. Limthongthang et al have shown that various plates offer a variety of prominence profiles, which may relate to tendon rupture.¹⁸ The association between implant design and complication reporting may serve as an area for potential future research.

There are several limitations to this survey study. Terminology used in the survey, including “watershed” and “critical line” were not explicitly defined. As with any questionnaire, there is a possibility of nonresponder bias.^{7,16} Attempts to increase response rate included adding a cover

letter message, incentivizing participation by keeping the survey length to a minimum and sending a reminder message several weeks after the initial request. Our response rate of 20% is similar to previous published survey studies.^{5,13} Demographic data of ASSH members, although not currently available to our knowledge, would assist future survey studies in assessing nonresponder bias among this population.^{7,16} Despite this limitation, the respondents are varied in their duration of practice. A majority of respondents reported practicing over 15 years, the significance of which is unknown. Measurement error is also possible as participating surgeons were asked to retrospectively recall past treatments. An attempt to improve reliability was made by simplifying questions to yield responses that reflected only a small, temporally defined interval of clinical experience. The experience of non-ASSH member surgeons who also treat distal radius fractures with volar plate internal fixation is not included in the study. An exact incidence or prevalence for tendon rupture after volar plating was unable to be determined by the study design. Confidential responses among individual questions did not permit a calculation of surgical complications encountered per surgical procedures performed for each respondent. Furthermore, the polled surgeons are hand specialists potentially treating referred complications in addition to their respective distal radius volar plate case volume. Nevertheless, the collective number of tendon ruptures reported in the study was much larger than previously published data, and the study design permitted an estimation of the ratio of patients with tendon injury compared with index volar plating cases.

Although not extensively described, experience from a subset of hand surgeons suggests that both flexor and extensor tendon ruptures can occur following volar plating of the distal radius. Surgeons should have a high index of suspicion when clinical symptoms are suggestive of tendon irritation during follow-up of patients managed with volar plating. Although systematic scrutiny of radiographic images may assist in stratifying and identifying patients at risk for tendon rupture, the responding hand surgeons did not consistently report using standardized methods. Tendon transfer appears to be one helpful option in managing tendon complications. Future studies should aim to identify additional risk factors and to optimize treatment strategies for tendon rupture following volar plating of distal radius fractures.

Appendix

Tendon Rupture Following Distal Radius Plating

1. How many years have you been in practice?

0	1-4	5-9	10-14	15+
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2. How many distal radius fractures did you manage with volar plating over the past year? How many distal radius fractures did you manage with dorsal plating over the past year?

	Volar	Dorsal
0		
1-9		
10-19		
20-49		
50+		

3. When do you remove volar plates? (Select all that apply)

I remove volar plates when the hardware is symptomatic and/or the hardware is malpositioned
 I remove volar plates when performing a secondary soft tissue procedure or arthroscopy
 I remove volar plates when considering stiffness/tenolysis/contracture release
 I always remove volar plates
 I never remove volar plates

4. How many patients with complete flexor tendon ruptures following volar plating of distal radius fractures have you encountered over the past year?

0	1	2	3	4	5	6	7	8	9	10+
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5. How many of each of the following flexor tendon injuries following volar plating of distal radius fractures have you encountered over the past year?

	No. of each type of flexor tendon rupture										
FPL	0	1	2	3	4	5	6	7	8	9	10+
FDP to index rupture	0	1	2	3	4	5	6	7	8	9	10+
FDS to index rupture	0	1	2	3	4	5	6	7	8	9	10+
FDP to long finger rupture	0	1	2	3	4	5	6	7	8	9	10+
FDS to long finger rupture	0	1	2	3	4	5	6	7	8	9	10+
Other (please specify tendon and number of each)											

6. How many of each of the following methods of repair did you employ for flexor tendon injuries following volar plating of distal radius fractures over the past year?

	No. of each type of flexor tendon repair method										
End-to-end repair	0	1	2	3	4	5	6	7	8	9	10+
FPL tenodesis	0	1	2	3	4	5	6	7	8	9	10+
Palmaris longus tendon graft	0	1	2	3	4	5	6	7	8	9	10+
Other tendon graft	0	1	2	3	4	5	6	7	8	9	10+
Tendon transfer (end to side, side to side, distal tendon to adjacent intact tendon)	0	1	2	3	4	5	6	7	8	9	10+
Digital joint arthrodesis/fusion	0	1	2	3	4	5	6	7	8	9	10+
Other (please specify tendon and number of each)											

7. How many of the volar plates removed for symptomatic tendon irritation or rupture over the past year were proximal and distal to the watershed line, respectively?

	No. of plates										
Proximal to the watershed line	0	1	2	3	4	5	6	7	8	9	10+
Distal to the watershed line	0	1	2	3	4	5	6	7	8	9	10+
At the watershed line	0	1	2	3	4	5	6	7	8	9	10+
Did not assess	0	1	2	3	4	5	6	7	8	9	10+
Do not remember	0	1	2	3	4	5	6	7	8	9	10+

8. How many of the volar plates removed for symptomatic tendon irritation or rupture over the past year were classified as grade 0, 1, or 2, respectively, according to the Soong grading system (description given below)?

	No. of plates										
Grade 0: Plate did not extend volar to the critical line	0	1	2	3	4	5	6	7	8	9	10+
Grade 1: Plate volar to the critical line, proximal to the volar rim	0	1	2	3	4	5	6	7	8	9	10+
Grade 2: Plate on the critical line, distal to the volar rim	0	1	2	3	4	5	6	7	8	9	10+
Do not use this classification routinely in my clinical practice	0	1	2	3	4	5	6	7	8	9	10+

9. How many complete extensor tendon ruptures following volar plating of distal radius fractures have you encountered over the past year?

	No. of extensor tendon ruptures										
Total no. of extensor tendon ruptures	0	1	2	3	4	5	6	7	8	9	10+

10. How many of each of the following extensor tendon injuries following volar plating of distal radius fractures have you encountered over the past year?

	No. of each type of extensor tendon rupture										
EPL	0	1	2	3	4	5	6	7	8	9	10+
EIP	0	1	2	3	4	5	6	7	8	9	10+
EDC	0	1	2	3	4	5	6	7	8	9	10+
Other (please specify tendon and number of each)											

11. How many of each of the following methods of repair did you employ for extensor tendon injuries following volar plating of distal radius fractures over the past year?

	No. of each type of extensor tendon rupture repair method										
Primary repair	0	1	2	3	4	5	6	7	8	9	10+
Tendon grafting	0	1	2	3	4	5	6	7	8	9	10+
Tendon transfer	0	1	2	3	4	5	6	7	8	9	10+
Other (please specify tendon and number of each)											

12. Do you routinely repair the pronator quadratus in fixing distal radius fractures?

Yes, always

No, never

Sometimes, depends on patient and/or fracture characteristics

Note. FPL, flexor pollicis longus; FDP, flexor digitorum profundus; EPL, extensor pollicis longus; EIP, extensor indicis proprius; EDC, extensor digitorum communis; FDS, flexor digitorum superficialis.

Ethical Approval

This study was approved by our institutional review board.

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.

Statement of Informed Consent

Informed consent was obtained from all patients for being included in the study.

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.

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