International Journal of Medical Imaging
2022; 10(2): 10-15
http://www.sciencepublishinggroup.com/j/ijmi
doi: 10.11648/j.ijmi.20221002.11
ISSN: 2330-8303 (Print); ISSN: 2330-832X (Online)

Hand Flexor Tendons Healing Assessment by Ultrasound After Primary Surgical Repair with and Without Intra Operative Injection of Platelet Rich Plasma (PRP)

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To cite this article:

Mohamed Salah Elfeshawy, Mohamed Osama Ouf, Ahmed Rami Majeed. Hand Flexor Tendons Healing Assessment by Ultrasound After Primary Surgical Repair with and Without Intra Operative Injection of Platelet Rich Plasma (PRP). *International Journal of Medical Imaging*. Vol. 10, No. 2, 2022, pp. 10-15. doi: 10.11648/j.ijmi.20221002.11

Received: March 4, 2022; **Accepted**: April 7, 2022; **Published**: April 14, 2022

Abstract: *Introduction:* Tendon injury represents a common cause of morbidity worldwide and of the commonest causes of disability especially among the worker group. *Aims:* Assessment of early healing progress and exclusion of any deviation in normal healing process using high resolution ultrasound regarding the changes in morphology and function of deep flexor tendon after surgical repair with and without PRP injection and correlate ultrasound picture with clinical outcome to reduce the post operative immobility period. *Setting and design:* Prospective, controlled study. *Method and materials:* We included 40 patients and compared between tendon healing and the early return to activities. 20 patients had an intraoperative PRP injection, while 20 others did not. *Results:* All repaired tendons in both groups shows a spindle like shape after 2 week. A persistent spindle shape of the tendon in ultrasound more than 12 weeks was related to significant improvement of tendon excursion and better dynamic movement of the repaired tendons ($p < 0.05$). The increased Power Doppler signal of the tendons more than 12 weeks was related to a significant increased tendon excursion and a so better dynamic movement of the fingers ($p < 0.05$). Ultrasound shows that PRP injection in primary tendon repair significantly improved the time needed to resume activities after tendon injuries, with a median of 6 weeks (SD 6-8) in Control Group and a median of 4 weeks (SD 4-6) in PRP Group. Post-operative pain was significantly improved in the second and third week in the PRP Group. *Conclusions:* The gray scale and Duplex ultrasound might be useful to rate and predict outcome of repaired tendon, reduce the post operative immobility period and rapid regain of hand function.

Keywords: Ultrasound, Flexor Tendon Repair, Efficacy of PRP Injection

1. Introduction

The postoperative appraisal of the healing progress of the repaired tendon is as yet restricted to clinical inspection and movement assessment whether passive or active.[1] Yet, by clinical examination we can't seen the tendon its self, the site of repair, gapped or not and degree of vascularity within. [2]

Now we can assess the repaired tendon itself and monitor the changes of healing progress and predict the outcome by using the High-frequency ultrasound which is noninvasive, repeatable, and sensibly reasonable indicative instrument. [3]

The early postoperative ultrasound is important for anyone is concerned, No information about the ultrasound picture of the tendon during different stage of healing progress. [4] Moreover, little data accessible on the genuine measure of movement at suture site. [5]

Hence, the aim of this study is prospective analysis the changes of morphology and function in early postoperative and during healing progress of repaired flexor tendon of the hand using a dedicated high-frequency ultrasound and correlate the sonographic data with clinical examination.

In this study we follow the morphological changes of the sutured tendon and its contiguous constructions, determined to distinguish morphological example of healing progress.

Moreover, the study assessed the degree of tendon mobility at repair site of utilizing sonographic scar tracking.

2. Methods

We performed a prospective controlled clinical study included 40 patients visiting Al-Azhar university hospital's emergency departments, 20 of them treated with the conventional method, the other 20 patients treated in the conventional method + PRP injection the cases treated and followed over period of December 2019 till October 2020.

2.1. Inclusion Criteria

Primary tendon injury, Patient age ranged from 15-60 years old, Males and females without selection, Hand tendons injury flexure, zone 2 to zone 6 tendon injury, Complete tendon cut.

2.2. Exclusion Criteria

younger than 15 years, older than 60 years, Partial tendon cut, Old cut, infected wound, associated skeletal injuries, Associated nerve or vascular injury related to the muscle (tendon) planned to be repaired.

2.3. Control Group

In which 20 cases with flexor tendon injury (complete cut) had been repaired by double modified Kessler + orientation continuous suture only.

2.4. PRP Group

In which 20 cases with flexor tendon injury (complete cut) had been repaired by double modified Kessler + orientation continuous suture augmented by autologous PRP injection in and around tendon repair site.

Figure 1. *Showing delicate injection of PRP to the tendon of FPL of the Left hand of one of our patients.*

2.5. Pre-operative Investigation

CBC, PT, PTT, INR, Viral screen, and limb x-ray to exclude any associated fracture.

2.6. Post-Operative Ultrasound

a. The study was down in AL-Hussein University Hospital – Cairo, Egypt, radiology department.
b. 2 weeks post-operative the patients got musculoskeletal ultrasound (Toshiba, Aplio 500 Platinum), using high frequency linear probe 12 MH.
c. We assess 8 points in the tendon:
   1) Longitudinal section tendon assessment. (Good VS Bad).
   2) Transverse section tendon assessment. (Good VS Bad).
   3) Tendon vascularity assessment by Doppler ultrasonography. (Good VS Bad).
   4) Dynamic imagining assessment of the tendon movement (passive) (Good VS Bad).
   5) Assessment of the shape and Stump echogenicity. (Good VS Bad).
   6) Stump adaptation and maximal anteroposterior diameter at the level of suturing. (Good VS Bad).
   7) Soft tissue changes surrounding the tendon and presence of adhesions between tendon and the surrounding structures. (Good VS Bad).
   8) Assessment the degree of repaired tendon suture site edema by measuring tendon diameter at site of suture and divide it through the other hand healthy tendon diameter (Good VS Bad).

At the first visit, 2 weeks after surgery, all tendons showed spindle like appearance. 12 weeks later, 50% of the tendons showed normal shape, and the remaining 50% still showed a spindle like shape. Apart from one sutured tendon showed gapping of 7 mm, all other sutured tendon showed contiguous stumps with no gapping.

At the first visit, 2 weeks after surgery, more than 90% of the repaired tendons showed inhomogeneous hypoechogenic stumps. During the healing progress, the suture sites become more hyper-echogenic. Three months later, 27% of repaired tendons showed inhomogeneous hyperechogenic appearance.

The suture site display hyperechogenic lines in parallel fashion looking like “railway track”.

At site of suture, The maximum tendons diameters were reached a after 3 to 5 weeks, and relapse somewhat till 12 weeks in comparison with the sound side.

Power Doppler study at day 14 revealed increased signal in more than 50% of all tendons weeks in comparison with the sound side. After 3 months, 40% of all tendons still showed hyperperfused power Doppler pattern.

2.7. Assessment Movement of the Tendon, (Dynamic)

The FDP tendon excursion was continuously improved after 12 weeks to 2.00 ± 0.42 mm ($p = 0.2$, 95% CI, −0.55–3.25). After 3 months, the mean TAM was to 114 ± 13°, representing good response.

A persistent spindle shape of the tendon in ultrasound

more than 3 months was related to a significant increased tendon excursion (2.86 ± 0.61 mm vs 1.14 ± 0.27 mm; $p < 0.05$; 95% CI, 0.2–0.35).

The increased Power Doppler signal of the tendons more than 12 weeks was related to significant increase of tendon excursion and dynamic movement of the fingers (3.13 ± 0.70 mm vs 1.25 ± 0.6 mm; $p < 0.05$; 95% CI, −3.33 to −0.41).

Figure 2. *Patient assessment by Ultrasound for one patient.*

Figure 3. *Ultrasonography for the contralateral healthy side for comparison with the repaired tendon for healing assessment.*

Figure 4. *Ultrasound cross section image of the tendon proximal to the suture site.*

Figure 5. *Ultrasound cross section image of the site of suture shows hyperechogenic parallel lines and assessment of degree of tendon edema.*

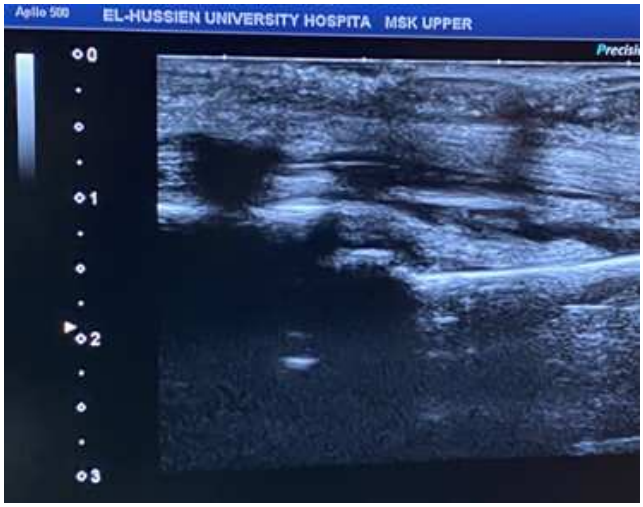

Figure 6. *Ultrasound longitudinal image of the repaired tendon shows complete continuity with no disruption.*

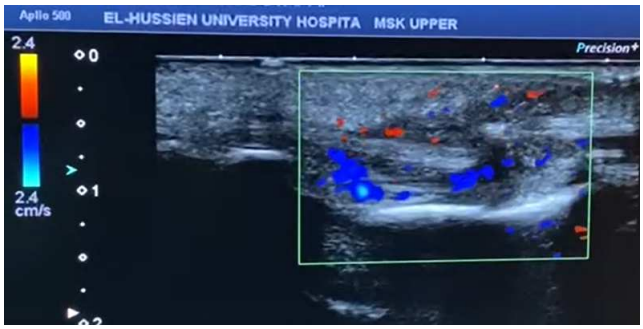

Figure 7. *Colour Doppler ultrasound at suture site to assess the degree of tendon vascularity.*

2.8. Analysis of Data

We used (SPSS), Statistical Package for Social Science. Methods of presenting data and tests used for comparison: P value < 0.05, considered significant, Mean ± Standard Deviation.

3. Result

The study had been carried out on 40 patients have flexor tendon injury, the cases had been managed in Al-Azhar

University Hospitals Cairo, Egypt. We had two groups. patient got PRP injection to augment tendon repair (Group I) and TENDON repaired without PRP Augmentation (Group II), table 1 show the comparison between the age regarding the two groups, The mean age in group I was 29.7 SD 9.6, where is in group II, it was 30.8 SD 9.2, There was no significant statistically difference *(p-value > 0.05)* between both groups regarding the age.

Table 1. *Comparison between both groups regarding the age.*

		Group I (N = 20)	Group II (N = 20)	T	P-value
Age (years)	Mean ±SD	29.7 9.6	30.8 9.2	0.35	0.726 NS

T: (Independent sample). T test. NS: p-value > 0.05 is non-significant.

The table revealed no significant difference regarding the age in both groups.

Table 2. *Comparison between both groups regarding the sex.*

		Group I (N = 20)		Group II (N = 20)		X^2	P-value
Sex	Male	12	60%	12	60%	0.0	1.0 NS
	Female	8	40%	8	40%		

X^2: Chi-square test.

The table revealed no significant difference regarding the sex between both groups.

Table 3. *Comparison between both groups regarding the affected side.*

		Group I		Group II		X^2	P-value
Affected side	Dominant	15	75%	16	80%	0.14	0.705 NS
	Non-dominant	5	25%	4	20%		

The table revealed no significant difference regarding the affected side between both groups.

Table 4. *Comparison between both groups regarding the zone.*

		Group I		Group II		X^2	P-value
Zone	Zone II	6	30%	8	40%	0.508	0.917 NS
	Zone III	10	50%	8	50%		
	Zone IV	3	15%	3	15%		
	Zone V	1	5%	1	5%		

The table revealed no significant difference regarding the zone between both groups.

Table 5. *Comparison between both groups regarding the affected tendon.*

		Group I		Group II		X^2	P-value
Tendon	FDP	12	60%	8	40%	1.6	0.2 NS
	FDS	7	35%	9	45%	0.41	0.518 NS
	FPL	4	20%	5	25%	0.14	0.705 NS

The table revealed no significant difference regarding the affected tendon between both groups.

Table 6. *Comparison between both groups regarding the pain scale.*

Pain scale		Group I	Group II	MW	P-value
1st week	Median IQR	8 7 - 8	8 7 – 8	157	0.253 NS
2nd week	Median IQR	7 6 – 7	5.5 4 - 6	94.5	0.004 S
3rd week	Median IQR	5.5 5 – 6	4 2 - 5	76	0.001 S

MW: Mann-Whitney U test. S: p-value < 0.05 is considered significant.
IQR: Interquartile range. NS: p-value > 0.05 is considered non-significant.

The table shows:

a. No significant difference between both groups regarding 1st week pain scale.
b. But significant statistically difference between both groups regarding 2nd & 3rd week pain scale.

Table 7. *Comparison between both groups regarding the Total Active Range Of Motion (TAROM)%.*

TAROM%		Group I	Group II	MW	P-value
1st week	Median	50	55	134.5	0.076 NS
	IQR	46.25 - 50	45 – 60		
2nd week	Median	55	65	131.5	0.063 NS
	IQR	51.25 – 58.75	50 - 65		
3rd week	Median	60	70	138.5	0.096 NS
	IQR	55 – 65	50 -75		

The table revealed no significant difference between both groups as regard 1st, 2nd & 3rd week TAROM%.

Table 8. *Comparison between both groups regarding the U/S assessment.*

		Group I		Group II		X^2	P-value
U/S	Poor	2	10%	1	5%	3.4	0.333 NS
	Fair	3	15%	3	15%		
	Good	12	60%	8	40%		
	Excellent	3	15%	8	40%		

The table revealed no significant statistically difference between both groups as regard U/S assessment.

Table 9. *Comparison between both groups as regard time of resuming activity.*

		Group I	Group II	MW	P-value
Time of resuming activity	Median	6	4	53.5	< 0.001 HS
	IQR	6 - 8	4 - 6		

MW: Mann-Whitney U test. HS: p-value < 0.001 is considered highly significant.

The table revealed high significant difference regarding time of resuming activity between both groups.

4. Discussion

Recently, the tendons morphology and architecture can be accurately assessed. By using high-frequency ultrasound transducers, we can asses and visualize the small superficial soft tissue the extremities. [6, 7]

High-frequency ultrasound transducers allow better contrast and spatial resolution, with limitation of narrow field of view and superficial imaging only which don't affect the imaging quality of flexor tendons of the finger. [8]

The financial weight of extensive stretches of nonattendance from work is self-evident, and the mission for an improvement in protocols of rehabilitation should proceed. [9] The objectives of a postoperative protocols of rehabilitation are to upset or forestall adhesions that interfere with better tendon movement and forestall joint stiffness. [10]

One point of the current study was to assess early changes in morphology of the tendon early after surgical repair using high frequency ultrasound assess the different morphological pattern throughout the healing progress. With respect to tendon morphology we distinguished two pattern. Despite the spindle like appearance of the most repaired tendons at 3 weeks post operatively, 50% of the all tendons showed normal shape 3 months post operatively.

Curiously, the ultrasound persistent spindle like shape and increased signal in power Doppler of the repaired tendon are associated with a better clinical outcome and better tendon excursion after 3 months follow up. This reflecting the dominant intrinsic healing factors and reduced possibility of adhesion. [11, 12]

On the other hand, if the extrinsic healing factors predominates will result in poor clinical outcome, persistence pain, adhesions between the repaired tendon and surrounding structures and consequent joint stiffness. [13]

Three stage of tendon healing are seen, the first phase is the inflammatory phase which start at 48 to 72 hours after repair, the second phase is the fibroblastic phase (or collagen-producing phase) which starts from 5 days to 4 weeks after repair and the third phase is the remodelling phase which continue up to 4 month after repair. [14, 15]

These different stages of tendon healing are correlated with changes of sonographic morphology in our study, the early predominantly hypoechogenic tendon pattern in 48 to 72 hours after repair correlates with the inflammatory phase as a result of edema and increased vascularity. [16] The predominantly hyperechoic tendon pattern in 2 weeks after repair correlates with delayed fibroblastic or collagen-producing phase and remodelling phases. [17, 18]

When comparing patient's characteristic in the two groups, no significant difference regarding age, sex, affected side, zone of injury and tendon affected between studied groups. However, there was statistical difference regarding 2nd and 3rd week pain scale follow up between studied group. No significant difference regarding 1st, 2nd & 3rd week TAROM%, between both group there was no significant statistically difference between both group regarding U/S assessment, However, there was statistical difference between studied group regarding time of resuming activities with median of 4 SD 4-6 in group 1 (PRP Group) (p-value < 0.05) and median of 6 weeks SD 6-8 in group 2 (Non-PRP).

5. Conclusions

This study shows the ultrasound persistent spindle like shape and increased power Doppler signal of the repaired tendon are associated with a better clinical outcome and reflecting dominant intrinsic healing factors and reduced possibility of adhesion. So gray scale and Duplex ultrasound might be useful to rate and predict outcome of repaired tendon. PRP Group show highly statistical difference regarding resuming activities post injury in comparison to the NON-PRP group.

List of Abbreviations

IQR: Interquartile range
PRP: Platelet Rich Plasma
TAROM: Total Active Range Of Motion
US: Ultrasound

Conflict of Interest

There were no competing interests.

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