European Journal of Plastic Surgery (2021) 44:237–242
https://doi.org/10.1007/s00238-020-01716-x

ORIGINAL PAPER

Flexor tendon repair outcomes with fat grafting

Ahmed A. Taha[1] · Ahmed Nour El Deen[1] · Mohamed Ragab[1] · Rama A. Ali[1]

Received: 13 April 2020 / Accepted: 20 July 2020 / Published online: 16 September 2020

Abstract

Background Young working adults frequently suffer from tendon injuries. However, despite the many advancements in repair techniques and postoperative physiotherapy programs that improved recovery, the benefit of fat injections in improving the outcome through their regenerative properties has remained under trial.

Methods A total of 50 patients with isolated flexor tendon injuries (zone II) presenting to the Emergency Department of Cairo University Hospitals from June 2018 to June 2019 were included and randomly divided into two groups. Group A cases received conventional tendon repair techniques without fat injection, whereas group B received fat injection as an adjunctive procedure after conventional repair. The outcomes were recorded and statistically analyzed.

Results Patients mean age was 25 years (range 17–50, standard deviation (SD) 2.4). The median for TAM (total active motion) in group A was 120 and 170, pre- and postoperatively. For group B, the median for TAM was 125 and 180, pre- and postoperatively. A comparison between both groups showed that group B had a higher postoperative median for TAM than group A ($p < 0.622$). However, both groups had similar postoperative medians for TPM (total passive motion) ($p < 0.379$).

Conclusions The current study showed that the fat injection group had increased TAM but decreased TPM. Although fat injection might help minimize adhesion formation after tendon repair, further work and research need to be done to understand why TPM decreased and whether it is related to joint stiffness or not.

Level of Evidence: Level III, therapeutic study.

Keywords Fat · Injection · Tendon · Repair · Outcomes

Introduction

Restoration of hand function following tendon injuries remains a real challenge, with young, healthy, male adults being mostly affected [1–4]. Given that timely and near-normal restoration of hand function is of utmost importance [5], many techniques have been developed and frequently revised.

Pittsburgh's team of plastic surgeons and researchers had discovered an abundance of adipose tissues with stem cells [6]. These adipose-derived stem cells (ASCs) have the potential to differentiate into other types of cells, such as tenocytes and myocytes [7], and have a paracrine function through the release of growth factors and cytokines [8].

Furthermore, adipose tissues are an excellent source of stromal vascular fractions (SVFs) that have repair and regenerative potential [9]. This may explain the role of fat grafting in accelerating the healing process and replacing damaged or missing cells. Currently, fat injection has become a popular procedure given its esthetic and reconstructive advantages [10].

Using fat grafting as an adjunct to tendon repair seems to be a promising concept due to its theoretical

✉ Ahmed A. Taha
dr.ahmed.ali.taha@gmail.com

[1] Department of Plastic Surgery, Faculty of Medicine, Cairo University, Kasr Al Ainy street, CAIRO 11562, Egypt

potential for enhancing tenocyte regeneration and organizing into structures that resemble a healthy functional tendon complex [11].

Studies have demonstrated various conditions in which fat grafting may enhance outcomes, some of which include tenodesis, partial to full-thickness tendon tears, interstitial tendon tears, ligament tears, muscle strains, and fibrous osteoarthritis [10, 12–15].

The present study investigates the role of fat injection on flexor tendon repair outcomes and recovery.

Patients and methods

A total of 50 patients with isolated single flexor tendon injury (zone II) in either the flexor digitorum profundus, flexor digitorum superficialis, or both who presented to the Emergency Department of Kasr Al Ainy Teaching Hospital, Cairo University, Egypt, from January 2018 to January 2019 were included. Any patient with associated vascular or nerve injury, multi-level tendon injury, or associated fracture, as well as those needing skin coverage, were excluded. This study had been approved by the local ethical committee (Plastic Surgery Department, Cairo University, Egypt). All patients provided verbal and written consent prior to the procedure. This study was conducted in accordance with the Declaration of Helsinki and the Medical Research Involving Human Subjects Act (WMO). Patient were randomized such that those who visited on Mondays, Wednesdays, and Saturdays were assigned to group A, while those who visited on Sundays, Tuesdays, and Thursdays were allocated to group B, with those visiting on Fridays being alternately allocated. All repairs were performed under general anesthesia with tourniquet application. Group A received conventional tendon repair without fat injection, whereas group B received harvested fat injections around repaired tendons just before closure.

Operative procedure

The procedure started with wound cleansing and irrigation, followed by local wound exploration. After both tendinous ends were identified, they were repaired using a core suture (double-stranded modified Kessler technique) with monofilament, synthetic, polyproline USP 3/0 suture followed by epi-tendinous USP 5/0 sutures. The pulley system was repaired mainly at the A2 and A4 pulleys sites, if needed.

Fat injection technique

Fat was harvested from in the inner thigh. This is easily accessible during the supine position. After infiltration, 10 cm^3 of fat was harvested using a 2-mm harvesting cannula and then centrifuged at 3000 rpm for 2 min. The low, dense oil layer and the high dense blood and anesthetic were discarded, while the remaining central fat layer was transferred to 1-cm^3 Luer-lock syringes. A 16G cannula was used for injecting 1–2 cm^3 of prepared fat through the wound after its closure.

Following repair, the hand was placed in a dorsal blocking splint (DBS) midway between flexion and extension (functional position of the hand).

Postoperative care

Following surgery, patients were scheduled to undergo weekly follow-ups for 4 weeks and monthly follow-ups thereafter. Both total passive motion (TPM) and total active motion (TAM) were assessed 6 months following surgery.

Outcome evaluation

Both groups were compared according to their efficacy for minimizing adhesions, which was calculated mainly through the TAM/TPM. Accordingly, a higher TAM suggests fewer adhesions and vice versa. Additionally, functional outcome was assessed using Strickland criteria in which the TAM for both proximal interphalangeal (PIP) and distal interphalangeal (DIP) joints is summed and compared with that for a contralateral non-injured finger (Table 1) [16].

Statistical analysis

Results are expressed as mean ± standard deviation (SD), median, minimum, maximum, or number (%). Categorical data (number (%)) were compared using the Chi-square test. According to the test of normality,

Table 1 Strickland criteria for assessing outcomes of flexor tendon repair

Outcome	Percentage
Excellent	85–100%
Good	70–84%
Fair	50–69%
Poor	< 50%

comparisons of different variables between two groups were performed using either unpaired t test or Mann–Whitney test as appropriate. According to the test of normality, comparisons between pre- and post-surgery variables within the same group were performed using the Wilcoxon Signed Ranks test. Percent change was calculated as follows: [(mean of post−mean of pre)/mean of post] × 100 or vice versa as appropriate. The Statistical Package for Social Sciences (version 19 for Windows) was used for data analysis, with a p value of ≤ 0.05 being considered significant [17].

Results

Included patients had a mean age of 25 years old (range 17–50, SD 2.4).

Postoperative results

Table 2 summarizes the TAM and TPM values before and after surgery (for both groups collectively).

Table 3 summarizes the median pre- and postoperative TAM values (again, for both groups). Our results showed significant improvement in postoperative TAM values, suggesting a good functional recovery.

A comparison between the median TPM pre- and postoperative values (for both groups) showed that the TPM decreased postoperatively in both groups (Table 4), possibly indicating postoperative joint stiffness ($p = 0.026$).

A comparison between groups A and B showed that group B (fat injection group) had a greater TAM postoperatively ($p = 0.622$) (Table 5). However, no change in TPM postoperatively had been observed in both groups (Table 6).

Table 7 presents the functional outcomes of flexor tendon repair using the Strickland criteria.

Table 2 Summary of total active motion and total passive motion in both groups

	TAM pre	TAM post	TPM pre	TPM post
Mean	81.15	171.15	220.58	214.23
Std. deviation	66.31	23.55	26.85	28.45
Std. error	13.00	4.62	5.27	5.58
Median	122.5	180.0	230.0	220.0
Minimum	0.0.0	130.0	170.0	150.0
Maximum	150.0	210.0	260.0	260.0

TAM, total active motion; *TPM*, total passive motion

Table 3 Comparison of median total active motion values in both groups measured before and after surgery

	Before surgery ($n = 50$)	After surgery ($n = 50$)	p value
Median (min–max)	122.5 (0.0–150.0)	180.0 (130.0–210.0)	0.001*

*$p < 0.05$ = significant

Complications

The most frequent complication observed was infection, accounting for a total of 9 cases (18%) of which three were in group A and six were in group B. All infections were successfully treated with adequate dressings and antibiotic coverage.

Joint stiffness was observed in a total of six digits (two in group A and four in group B).

Repair failure (not related to infection) occurred in five patients, four of whom were in group A.

Flexion contracture occurred in 4 cases (8%) equally distributed between both groups. All complications involved either failed repair or poor postoperative outcomes. The remaining population (68%) had a smooth postoperative outcome.

Discussion

Despite the evolution and advancements in tendon surgeries throughout the past decades, a significant proportion of patients has experienced unsatisfactory results. This is primarily due to adhesions between the tendon and its surrounding tissues [18–20]. Consequently, hand surgeons have started adopting protocols to minimize adhesions and hence improve tendon gliding.

Table 4 Comparison between median total passive motion values in both groups measured before and after surgery

	Before surgery ($n = 50$)	After surgery ($n = 50$)	p value
Median (min–max)	230.0(170.0–260.0)	220.0 (150.0–260.0)	0.026

*$p > 0.05$ = insignificant

Table 5 Comparison of median total active motion values measured before and after surgery between both groups

	Group A (no fat injection) ($n = 25$)	Group B (fat injection) ($n = 25$)	p value
Pre-surgery	120 (0–150)	125 (0–150)	0.915
Post-surgery	170 (130–210)	180 (130–200)	0.622
Percent change	52.3 ↑↑	52.9 ↑↑	
p value	0.001*	0.001*	

Data are expressed as median (min–max)

Table 7 Functional outcome results according to the Strickland criteria

	Total	Group A (no fat injection)	Group B (fat injection)	Percentage
Excellent	11	5	6	22%
Good	11	5	6	22%
Fair	10	5	5	20%
Poor	13	6	7	26%
Failed	5	4	1	10%
Total	50	25	25	100%

The male predominance of the patients included herein reflects the higher incidence of upper-limb trauma among males, especially at a young age (mean age was 29 years). This highlights the substantial impact disabling injuries within this special population have on society [1–5].

All repairs were done using the modified Kessler technique to avoid bulky repair and hence ensuring smoother and easier tendon gliding [21]. The standard rehabilitation program implemented was the Kleinert protocol, which aimed at minimizing adhesion formation [18].

Adhesion formation was assessed by calculating the mean difference between the TAM and TPM. The discrepancy between the TAMs has been shown to be a more reliable measure for evaluating adhesion formation than the Strickland criteria, which depend solely on the return of motion. This is because adhesions mainly affect the TAM, while joint stiffness causes a global decrease in both the TAM and TPM [22].

The present study showed that patients who received fat injections had less adhesion formation compared with those managed without fat injections. However, differences between both groups were not statistically significant.

Table 6 Comparison of median total passive motion values measured before and after surgery between both groups

	Group A (no fat injection) ($n = 25$)	Group B (fat injection) ($n = 25$)	p value
Pre-surgery	230 (170–260)	230 (175–250)	0.402
Post-surgery	220 (170–260)	220 (150–250)	0.379
Percent change	2.4 ↓↓	3.4 ↓↓	
p value	0.102	0.109	

Those who received fat injections had a higher infection rate than those without fat injections, which may have been attributed to the survival of fat, as well as its necrosis and death.

While a significant difference in the TAM after surgery had been observed for the whole population, no significant difference was observed between groups A and B.

No significant difference in the TPM had been observed, which suggests that injection had no influence on passive range of motion. This indicates that the postoperative decrease in the TPM was unrelated to adhesion formation and could probably be attributable to joint stiffness, which is a common sequela following tendon injuries [22–24].

Our results for functional outcome were nearly like those presented in similar studies. Accordingly, Hoffman and colleagues reported that 43% of patients who had underwent Kessler repair had excellent to good results, with an 11% rupture rate [25]. Among the patients included in the present study, 44% reported excellent to good results, although nearly 36% had failed or poor outcomes. This can be partially explained by the patients' non-compliance to rehabilitation programs, which is quite common among developing countries [26–29].

The anatomy of the flexor tendon, as well as its blood supply and excursion, is quite unique and differs from that of the extensor tendons [30]. This study included only the patients with flexor tendon (zone II) injuries to precisely determine whether the results were mainly due to the variable used, which was fat injection.

Despite all the efforts, our study has limitations worth noting. The relatively small population and the inclusion of only flexor tendon are among such limitations. Future multicenter studies that include larger cohorts and various tendons (e.g., flexors and extensors) are therefore needed for better statistical significance.

Conclusions

The current study showed that the fat injection group had increased TAM but decreased TPM. Although fat injection might help minimize adhesion formation after tendon repair, further work and research need to be done to understand why TPM decreased and whether it is related to joint stiffness or not.

Authors' contribution All authors have made substantial contributions to all of the following: (1) the conception and design of the study, acquisition of data, and analysis and interpretation of data; (2) drafting of the article or critical revisions for important intellectual content; and (3) final approval of the version to be submitted.

Funding This research did not receive any specific grant from any funding agency in the public, commercial, or not-for-profit sector.

Data availability The manuscript, including related data, figures, and tables, has not been previously published and is not under consideration elsewhere.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Ethical approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. The Ethical Committee of Cairo University (Egypt) approved this study.

Informed consent Informed consent was obtained from all individual participants included in the study. Patients provided verbal and written consent for the procedure. Patients signed informed consent regarding publishing their data and photographs.

References

1. Kaisha WO, Khainga S (2008) Causes and pattern of unilateral hand injuries. East Afr Med J 85(3):123–128
2. Shrestha KM, Pandey A, Shrestha B (2017) Pattern of hand injuries in a teaching hospital of a developing country. J Univ Coll Med Sci 05(01 Issue 15)
3. Rex DO, Adesina A (2015) Pattern of hand injuries seen in the accident and emergency unit of an urban orthopedic hospital. Niger J Plast Surg 11(1):8–11
4. Grinsell D, Keating CP (2014) Peripheral nerve reconstruction after injury: a review of clinical and experimental therapies. Biomed Res Int:698256
5. Matsuzaki H, Narisawa H, Miwa H, Toishi S (2009) Predicting functional recovery and return to work after mutilating hand injuries: usefulness of Campbell's Hand Injury Severity Score. J Hand Surg Am 34(5):880–885
6. James IB, Coleman SR, Rubin JP (2016) Fat, stem cells, and platelet-rich plasma. Clin Plast Surg 43(3):473–488
7. Zuk PA, Zhu M, Mizuno H et al (2001) Multilineage cells from human adipose tissue: implications for cell-based therapies. Tissue Eng 7:221–228
8. Guilak F, Estes B, Diekman B et al (2010) Nicolas Andry Award: multipotent adult stem cells from adipose tissue for musculoskeletal tissue engineering. Clin Orthop Relat Res 9:2530–2540
9. Bora P, Majumdar AS (2017) Adipose tissue-derived stromal vascular fraction in regenerative medicine: a brief review on biology and translation. Stem Cell Res Ther 8(1):145
10. Oliver KS, Alexander RW (2013) Combination of autologous adipose –derived stromal vascular fraction plus high density platelet - rich plasma or bone marrow concentrates in Achiles tendon tear. J Prolother 5:e895–e912
11. Mozzola RF, Mazzola IC (2015) History of fat grafting from Ram fat to stem cells. Clin Plast Surg 42:147–153
12. Simonacci F, Bertozzi N, Grieco MP et al (2017) Procedure, applications, and outcomes of autologous fat grafting. Ann Med Surg 20: 49–60
13. Benjamin MA, Schwarzman G, Eivazi M et al (2015) Autologous staged fat tissue transfer in post-traumatic lower extremity reconstruction. J Surg Case Rep (11):rjv141
14. Adriani E, Moio M, Di Paola B et al (2017) Percutaneous fat transfer to treat knee osteoarthritis symptoms: preliminary results. Joints 5(2):89–92
15. Herold C, Rennekampff HO, Groddeck R et al (2017) Autologous fat transfer for thumb carpometacarpal joint osteoarthritis: a prospective study. Plast Reconstr Surg 140(2):327335
16. Strickland JW, Glogovac SV (1980) Digital function following flexor tendon repair in zone II: a comparison of immobilization and controlled passive motion techniques. J Hand Surg [Am] 5(6):537–543
17. IBM Corp. Released 2010. IBM SPSS statistics for windows, version 19.0. IBM Corp, Armonk
18. Kleinert HE, Spokevicius S, Papas NH (1995) History of flexor tendon repair. J Hand Surg [Am] 20(pt2):s46–s52
19. Strickland JW (2000) Developing of flexor tendon surgery: twenty five years of progress. J Hand Surg [Am] 20:241–235
20. Williamson DJ, Richards RS (2006) FRCSC. Flexor tendon injury and reconstruction. In: Mathes SJ, McCarthy MD (eds) Plastic Surgery, 2nd edn. Sunders, Philadelphia, p 356
21. Trumble TE, Vedder NB, Seiler JG et al (2010) Zone-II flexor tendon repair: a randomized prospective trial of active place-and-hold therapy compared with passive motion therapy. J Bone Joint Surg Am 92(6):1381–1389
22. Groth GN (2004) Pyramid of progressive force exercises to the injured flexor tendon. J Hand Ther 17(1):31–42
23. Yang G, McGlinn EP, Chung KC (2014) Management of the stiff finger: evidence and outcomes. Clin Plast Surg 41(3):501–512
24. Kuczynski K (1968) The proximal interphalangeal joint. Anatomy and causes of stiffness in the fingers. J Bone Joint Surg Br 50:656–663
25. Hoffmann GL, Büchler U, Vögelin E (2008) Clinical results of flexor tendon repair in zone II using a six-strand double-loop technique compared with a two-strand technique. J Hand Surg Eur Vol 33(4):418–423
26. Groth GN, Wulf MB (1995) Compliance with hand rehabilitation: health beliefs and strategies. J Hand Ther 8(1):18–22

27. Ann-Marie Codori, Ellen D. Nannis, Arlynne D. Pack, The development of a clinical measure of compliance with hand rehabilitation, J Hand Ther, 1992, Volume 5, Issue 1, ,29–33
28. Turmusani M, Vreede A, Wirz SL (2002) Some ethical issues in community-based rehabilitation initiatives in developing countries. Disabil Rehabil 14(10):558–564
29. The World Health Organisation. (World report on disability 2011. Chapter 4: Rehabilitation)
30. Schreck M, Hammert WC (2018) Tenets of flexor and extensor tendon repair. Curr Orthop Pract 29(2):96–99