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COMPARING COMPLICATION RATES FOLLOWING VARIOUS TRAUMATIC TENDON REPAIR TECHNIQUES AT THE JORDANIAN ROYAL MEDICAL SERVICES

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ABSTRACT

Background: Tendon repair techniques have developed over the past years. The Modified Kessler technique has become recognized for its strong and simple nature. The Modified Bunnell technique creates a special pattern of strong and secure repair, as well as it is minimally invasive which lowers the risk of nerve damage and infections. The Running Interlocking Mattress Suture reduces the risk of slippage. However, Running Sutures are simple to apply and flexible. Previous literature studied the advantages and disadvantages of tendon repair techniques, but a specific analysis to the Jordanian population is needed. **Objective:** This study was conducted to study the percentage of complications for specific tendon repair techniques. **Methods**: A retrospective study of medical records at King Hussein Medical Center (KHMC) between 2021 and 2024. 2,500 patients were included in this cohort study and were classified by the tendon repair technique they had. Inclusion criteria included patients who are aged between 5 and 60 years old with acute tendon injuries, completed medical records and available follow-up information. Collected data involved demographic characteristics, details of surgery, and complications such as tendon rupture, deformities and adhesions. **Results:** Repair technique, diabetes, and time to surgery remained significant independent predictors of postoperative complications. The simple running technique was associated with more than a twofold increased risk of complications compared with the Modified Kessler method (OR = 2.02, 95% CI: 1.42–2.87, $p < 0.001$), whereas the Modified Bunnell and Running interlocking mattress techniques did not significantly differ from the reference group ($p > 0.05$). Diabetic patients had a higher likelihood of complications (OR = 1.49, 95% CI: 1.01–2.16, $p = 0.045$), and each additional hour of surgical delay modestly increased the risk (OR = 1.01, 95% CI: 1.00–1.02, $p = 0.035$). **Conclusion:** The study identified predictors of tendon repair postoperative complications such as repair technique applied, immunocompromised conditions such as diabetes, and prolonged delays before surgery. The Simple Running Technique was linked with increased risk of complications compared to Modified Kessler technique.

KEYWORDS: Retrospective, Jordan, Tendon, Trauma, Techniques.

INTRODUCTION

Tendon injuries are common in the hand and wrist, especially after trauma, leading to major dysfunction if not received the proper treatment.[1] Surgical management is considered as the cornerstone of treatment, as well as many techniques have been shown to improve strength and contribute to early mobilization.[2] Tendon repair is a surgical procedure aims to restore function and to lower complications possibilities such as rupture, adhesions or stiffness.[3] The Modified Kessler technique is a very well-known widely used method. Surgeons like this method because of its simplicity and reliable strength.[4] Overtime, modifications of this technique such as the Kirchmayr-Kessler and Kessler-Tsuge have been evolved to increase stability, enhance tendon gliding as well as to give improved support for early motion.[5] The Modified Bunnel technique is also a famous approach. This one is known for reducing the possibility of repair failure. However, it can be a more demanding technique.[6] In the

past few years, continuous suture techniques have been introduced. The Running Interlocking Horizontal Mattress (RIHM) method has shown good results in laboratory and clinical research. RIHM technique gives better stiffness, less shortening and shorter surgical period compared to other sutures.[7] Some studies have shown that RIHM repairs were associated with improved functional outcomes with less complications when comparing it to Modified Kessler repairs.[8] However, the choice of a specific tendon repair technique frequently depends on tendon type, area of injury, surgeon expertise and rehabilitation protocol, which makes it hard to choose one perfect technique for all patients.[9] Current studies note that a tendon repair technique should be a proper technique that gives strong repair and provide early mobilization at the same time, in order to help the patient recovers and receive the ideal method.[10]

This study aimed to study the percentage of complications for different tendon repair techniques, to compare the safety of these methods and to provide clinical recommendations in Jordan according to our results.

METHODS AND MATERIALS

Study Design

This study was a retrospective analysis involving 2,500 patients who underwent various tendon repair techniques at the Royal Jordanian Rehabilitation Centre (RJRC) within the King Hussein Medical Centre (KHMC) from 2021 to 2024. This study was conducted to study the percentage of complications for specific tendon repair techniques, to compare safety of various techniques, and to offer recommendations for clinical practice in Jordan based on our findings.

Data Collection

The study involved 2,500 patients. We obtained patient demographics, like age, gender, and occupation from medical records. Collected variables included surgical data, type of tendon repair technique employed and complications such as tendon rupture, adhesions with contractures, and shortening of tendon with flexion and extension deformity. The study's inclusion criteria included individuals aged 5 to 60 years with acute tendon injuries as well as comprehensive medical records and follow-up data. However, exclusion Criteria involved patients with chronic tendon injuries or those were older than the specified age group. All extracted data was recorded in a structured database for later statistical analysis.

Ethical Consideration

The approval of this study was gained by the Institutional Review Board (IRB) committee combined with the Jordanian Royal Medical Services (approval no: 12/13/2025). All study procedures were in accordance with the Declaration of Helsinki, 1964. Informed consent was waived by the committee due to the retrospective nature of data collection. All patients' data were anonymized and safely stored.

Statistical Method

Data were analyzed using descriptive and inferential statistics. Continuous variables were summarized as mean ± standard deviation (SD) or median with interquartile range (IQR), according to distribution, and compared across repair techniques using one-way ANOVA or the Mann–Whitney U test, as appropriate. Categorical variables were reported as counts (percentages) and compared using chi-square or Fisher's exact tests. Variables with $p < 0.05$ in univariable analyses were entered into a multivariable logistic regression to identify independent predictors of postoperative complications; results are presented as odds ratios (OR) with 95% confidence intervals (CI). All tests were two-tailed with a significance threshold of $p < 0.05$. Analyses were conducted in R (Vienna, Austria; version 4.3.2).

RESULTS

A total of 1,500 patients were included, most of whom were male (77%), with a mean age of 30 ± 11 years. Four tendon repair techniques were used: Modified Kessler (n = 517), Modified Bunnell (n = 384), Running interlocking mattress (n = 310), and simple running (n = 289). Baseline demographic and clinical variables were generally similar among techniques. Diabetes ranged from 11% to 13%, and smoking was reported in about one-third of patients. Injury distribution was similar among groups, with zone II being the most common (35%). The mean time to surgery was 20 ± 11 hours for all techniques.

There were postoperative complications in 19% of all patients, with the simple running group having the most complications (28%). The tendon ruptured in 4.1% of patients, and the percentages were the same among all techniques. Adhesion occurrence was observed in 7.7% of patients, ranging from 5.2% with Modified Kessler to 14% using the simple running technique.

When comparing patients with complications (n = 283) to those without (n = 1,217), several variables showed significant associations. Repair technique distribution differed notably ($p < 0.001$): the simple running method was used more often in patients with complications (29% vs. 17%), while the Modified Kessler method was more common among those without complications (36% vs. 29%). Diabetes was more observed in the complication group (16% vs. 11%, $p = 0.022$). Additionally, time to surgery was slightly longer in patients with complications (median 19 [14–26] hours) than in those without (18 [13–24] hours, $p = 0.014$). Age, sex, smoking, and injury zone showed no significant variations ($p > 0.05$).

In multivariable logistic regression, repair technique, diabetes, and time to surgery remained significant

independent predictors. The simple running technique carried more than twice the risk of complications compared with Modified Kessler (OR = 2.02, 95% CI: 1.42–2.87, p < 0.001). Diabetes increased complication risk (OR = 1.49, 95% CI: 1.01–2.16, p = 0.045). Each additional hour of surgical delay slightly increased risk (OR = 1.01, 95% CI: 1.00–1.02, p = 0.035). Age, sex, smoking, and injury zone were not independently associated.

Table 1: Baseline Characteristics and Postoperative Outcomes According to Repair Technique.

Characteristic	Modified Kessler N = 517	Modified Bunnell N = 384	Running interlocking mattress N = 310	Simple Running N = 289	Overall N = 1,500
Age (years)	29 ± 12	30 ± 11	31 ± 11	30 ± 12	30 ± 11
Sex					
Female	130 (25%)	91 (24%)	63 (20%)	59 (20%)	343 (23%)
Male	387 (75%)	293 (76%)	247 (80%)	230 (80%)	1,157 (77%)
Diabetes	65 (13%)	45 (12%)	36 (12%)	33 (11%)	179 (12%)
Smoker	173 (33%)	129 (34%)	93 (30%)	103 (36%)	498 (33%)
Injury zone					
I	77 (15%)	56 (15%)	40 (13%)	42 (15%)	215 (14%)
II	175 (34%)	134 (35%)	112 (36%)	109 (38%)	530 (35%)
III	102 (20%)	73 (19%)	65 (21%)	51 (18%)	291 (19%)
IV	71 (14%)	71 (18%)	46 (15%)	41 (14%)	229 (15%)
V	92 (18%)	50 (13%)	47 (15%)	46 (16%)	235 (16%)
Time to surgery (h)	20 ± 11	20 ± 11	20 ± 11	21 ± 14	20 ± 11
Any complication	83 (16%)	66 (17%)	53 (17%)	81 (28%)	283 (19%)
Rupture	22 (4.3%)	11 (2.9%)	17 (5.5%)	12 (4.2%)	62 (4.1%)
Adhesion	27 (5.2%)	29 (7.6%)	20 (6.5%)	40 (14%)	116 (7.7%)

Table 2: Comparison of Baseline and Surgical Characteristics Between Patients With and Without Complications.

Characteristic	No N = 1,217	Yes N = 283	p value
Adhesions	30 [22, 38]	29 [21, 37]	0.10
Sex			0.7
Female	281 (23%)	62 (22%)	
Male	936 (77%)	221 (78%)	
Diabetes	134 (11%)	45 (16%)	**0.022**
Smoker	399 (33%)	99 (35%)	0.5
Injury zone			0.3
I	175 (14%)	40 (14%)	
II	417 (34%)	113 (40%)	
III	237 (19%)	54 (19%)	
IV	187 (15%)	42 (15%)	
V	201 (17%)	34 (12%)	
Time to surgery (h)	18 [13, 24]	19 [14, 26]	**0.014**
Repair technique			**<0.001**
Modified Kessler	434 (36%)	83 (29%)	
Modified Bunnell	318 (26%)	66 (23%)	
Running interlocking mattress	257 (21%)	53 (19%)	
Running simple	208 (17%)	81 (29%)	

Table 3: Multivariable Logistic Regression Analysis of Factors Associated With Postoperative Complications.

Characteristic	OR	95% CI		P value
		Lower	Upper	
Repair technique				**<0.001**
Modified Kessler	-	-	-	
Modified Bunnell	1.08	0.76	1.55	
Running interlocking mattress	1.08	0.73	1.57	
Running simple	2.02	1.42	2.87	

Age (years)	0.99	0.98	1.00	0.14
Sex				0.7
Female	-	-	-	
Male	1.07	0.78	1.47	
Diabetes				**0.045**
No	-	-	-	
Yes	1.49	1.01	2.16	
Smoker				0.8
No	-	-	-	
Yes	1.04	0.78	1.37	
Injury zone				0.3
I	-	-	-	
II	1.16	0.78	1.76	
III	1.02	0.65	1.62	
IV	0.98	0.60	1.59	
V	0.72	0.43	1.20	
Time to surgery (h)	1.01	1.00	1.02	**0.035**

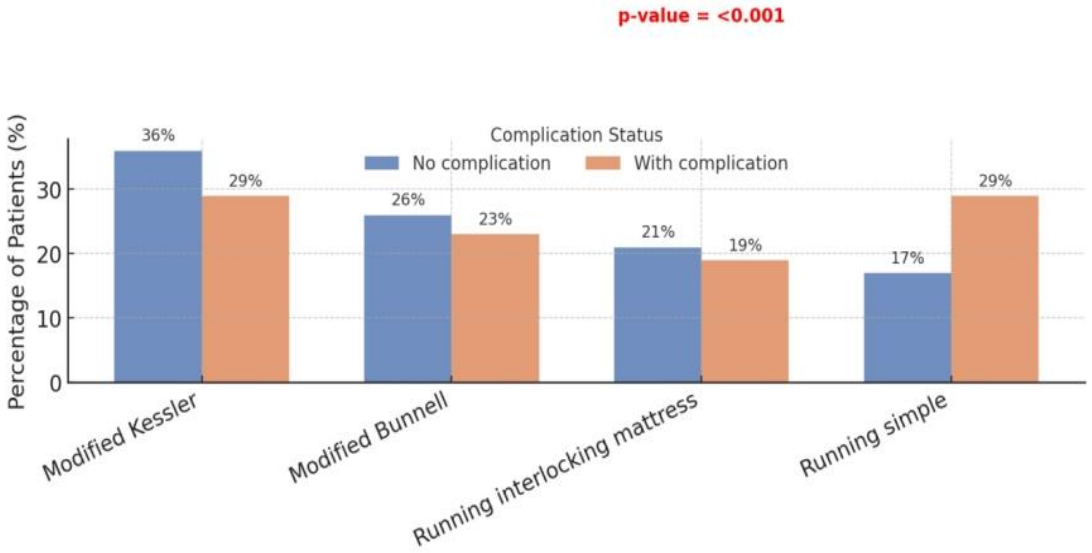

Figure 1: Repair Technique and overall Complication Rates.

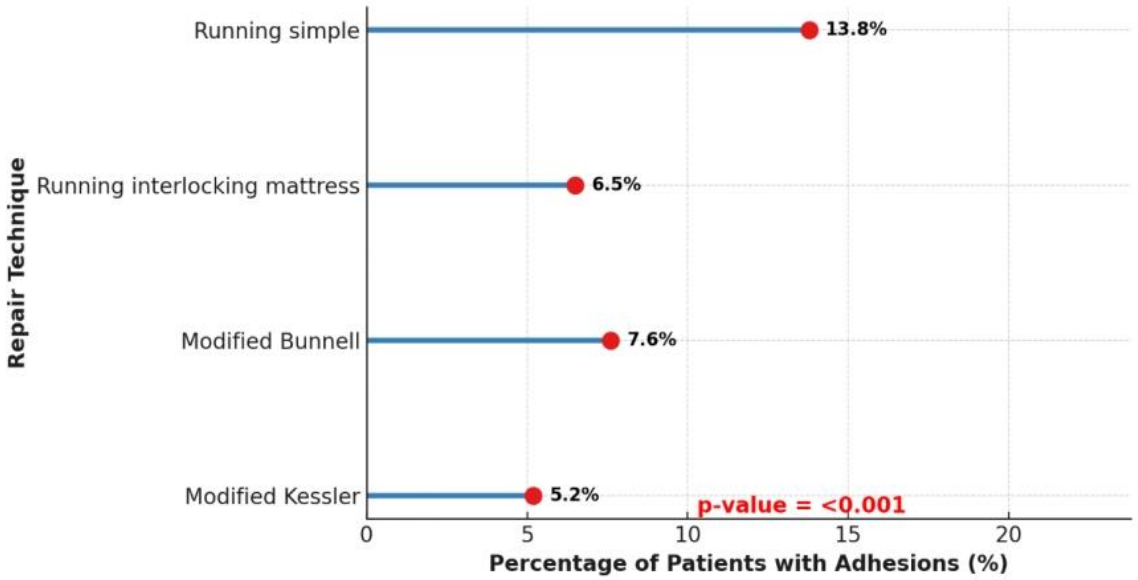

Figure 2: Adhesion Rates by Repair Technique.

DISCUSSION

Tendon disorders affect people of different age groups from athletes to elderly patients. Tendon healing occurs in three phases after an acute injury. The healed tendons don't restore its primary mechanical functions even after this procedure.[11] Tendon repair is crucial in plastic and hand surgery when aiming to restore function following an injury. Techniques have advanced from simple suturing to biologic therapy to improve the strength , reduce complications, and allow early mobilization.[12] Traditional approaches use core suture techniques (such as modified Kessler, Adelaide, Lim-Tsai, and Kessler), which are usually paired with peripheral sutures to give improved strength.[13],[14] Multistrand core sutures (four or six strands) are currently widely used for flexor tendon repairs, because of their improved tensile strength and resistance to gapping, supporting early active mobilization.[15] Achilles tendon ruptures can be treated with open, percutaneous, mini-open, or combination methods. Combined percutaneous and mini-open repairs have better functional outcomes and lower morbidity than percutaneous or open repairs alone.[16]

Our study aimed to assess the percentage of complications associated with various traumatic tendon repair techniques, compare the safety of these techniques and provide clinical practice recommendations in Jordan. Our study included a total of 1,500 patients, with the majority being male (77%). Modified Kessler, Modified Bunnell, Running interlocking mattress, and simple running baseline demographic and clinical variables were generally comparable. Complications occurred in 19% of patients overall in this cohort, with the simple running group (28%) being the highest incidence among all. Tendon rupture occurred in 4.1% of our cases. Adhesion formation was observed in 7.7% of our patients overall, ranging from 5.2% with the Modified Kessler technique to 14% with the simple running technique. A retrospective study of 615 patients who underwent acute Achilles tendon rupture repair, showed that 11.7% of patients had a postoperative complication. Reported risk factors were, advanced age and smoking.[17]

In our cohort, a higher proportion of patients with diabetes complained from complications. Additionally, time for surgery was slightly longer in patients with complications compared to those without. A systematic review of 43 articles included 2833 proximal hamstring tendon repairs, found that this technique was associated with complications in 15.3% of patients.[18] Another study reported that proper timing of surgery can help minimize complications following flexor tendon repair. A delay from 3 to 7 days in surgery was associated with higher risk of complications.[19] Aligning with our cohort, a systematic review had revealed that DM patients are 2.25 times more likely to experience tendon retear than those without DM.[20]

The study had significant limitations such as its retrospective nature and single center setting which restricted the generalizability of the findings. However, future prospective and multicenter research using standardized rehabilitation techniques are required to optimize results.

CONCLUSION

Our results suggest that tendon repair techniques, diabetic patients, and prolonged delays before surgery are all strong predictors that contribute to postoperative complications. The Simple Running technique was associated with more than twice greater risk of complications when compared with the Modified Kessler technique.

REFERENCES

1. Ka S, Jc C, Akm F, Jm P. PubMed. 2025 [cited 2025 Sep 11]. Flexor Tendon Lacerations. Available from: https://pubmed.ncbi.nlm.nih.gov/29630275/
2. Jp W, Dc S, Ag C, Sl M, Ak G. Practice Patterns in Operative Flexor Tendon Laceration Repair: A 15-Year Analysis of Continuous Certification Data from the American Board of Plastic Surgery. Plastic and reconstructive surgery Global open [Internet]. 2022 Oct 7 [cited 2025 Sep 11]; 10(10). Available from: https://pubmed.ncbi.nlm.nih.gov/36225846/
3. Flexor Tendon Repair: Avoidance and Management of Complications. Hand Clinics, Aug. 1, 2023; 39(3): 427–34.
4. A S, Ch L, Sk W, Sy L, Fa A, S S. A Survey of Zone II Flexor Tendon Repair Techniques and Rehabilitation Protocols Preferred by Malaysian Orthopaedic Practitioners. Malaysian orthopaedic journal [Internet]. 2022 Jul [cited 2025 Sep 11]; 16(2). Available from: https://pubmed.ncbi.nlm.nih.gov/35992993/
5. Schellnegger M, Lin AC, Holzer-Geissler JCJ, Haenel A, Pirrung F, Hecker A, et al. Biomechanical Comparison of Three Modified Kessler Techniques for Flexor Tendon Repair: Implications in Surgical Practice and Early Active Mobilization. Journal of Clinical Medicine, Jan. 2024; 13(19): 5766.
6. Ballesteros-Betancourt J, Rosales RS, García-Tarriño R, Rios J, Combalia-Aleu A, Llusá-Pérez M. A biomechanical comparison of the modified Bunnell pullout and Teo intraosseous suture techniques for attachment of tendon to bone. Journal of Hand Surgery (European Volume) [Internet]. 2019 Jul 8 [cited 2025 Sep 11]; Available from: https://journals.sagepub.com/doi/10.1177/1753193419859548
7. Uludağ A, Tosun HB, Çelik S, Serbest S, Kayalar M, Aytaç G, et al. Comparison of various tendon repair techniques in extansor zone 3 injuries: an experimental biomechanical cadaver study. Arch Orthop Trauma Surg, Apr. 1, 2020; 140(4): 583–90.
8. R S, S S, K D. Running Interlocking Horizontal Mattress-A New Technique versus Modified Kessler in Extensor Tendon Injuries: A Comparative Study.

Journal of hand and microsurgery [Internet]. 2021 Apr 13 [cited 2025 Sep 11]; 15(1). Available from: https://pubmed.ncbi.nlm.nih.gov/36761047/
9. Liu G, Lv G, Liu F. Suture techniques in the surgical management of flexor tendon, Achilles tendon and cruciate ligament injuries: a systematic review. BMC Musculoskelet Disord, Dec. 2024; 25(1): 1–13.
10. Passive Mobilization With Place-and-Hold Versus Active Mobilization Therapy After Flexor Tendon Repair: 5-Year Minimum Follow-Up of a Randomized Controlled Trial. The Journal of Hand Surgery, Dec. 1, 2024; 49(12): 1165–72.
11. C DL, F B, Lj S, B LG. Biology and physiology of tendon healing. Joint bone spine [Internet]. 2024 Sep [cited 2025 Oct 14]; 91(5). Available from: https://pubmed.ncbi.nlm.nih.gov/38307405/
12. Li ZJ, Yang QQ, Zhou YL. Basic Research on Tendon Repair: Strategies, Evaluation, and Development. Frontiers in Medicine, Jul. 28, 2021; 8: 664909.
13. Results of 4-strand modified Kessler core suture and epitendinous interlocking suture followed by modified Kleinert protocol for flexor tendon repairs in Zone 2 [Internet]. [cited 2025 Oct 14]. Available from: http://www.aott.org.tr/en/results-of-4-strand-modified-kessler-core-suture-and-epitendinous-interlocking-suture-followed-by-modified-kleinert-protocol-for-flexor-tendon-repairs-in-zone-2-133464
14. Wieskötter B, Herbort M, Langer M, Raschke MJ, Wähnert D. The impact of different peripheral suture techniques on the biomechanical stability in flexor tendon repair. Arch Orthop Trauma Surg, Jan. 1, 2018; 138(1): 139–45.
15. Tang JB, Lalonde D, Harhaus L, Sadek AF, Moriya K, Pan ZJ. Flexor tendon repair: recent changes and current methods. Journal of Hand Surgery (European Volume) [Internet]. 2021 Nov 5 [cited 2025 Oct 14]; Available from: https://journals.sagepub.com/doi/10.1177/17531934211053757
16. LWW [Internet]. [cited 2025 Oct 14]. A comprehensive review of surgical techniques for chronic... : Tzu Chi Medical Journal. Available from: https://journals.lww.com/tcmj/fulltext/2025/07000/a_comprehensive_review_of_surgical_techniques_for.3.aspx
17. Stavenuiter XJR, Lubberts B, Robert M. Prince III, Johnson AH, DiGiovanni CW, Guss D. Postoperative Complications Following Repair of Acute Achilles Tendon Rupture. Foot & Ankle International [Internet]. 2019 Feb 27 [cited 2025 Oct 14]; Available from: https://journals.sagepub.com/doi/10.1177/1071100719831371
18. Lawson JJ, Abraham EA, Imbergamo CM, Sequeira SB, Dreese JC, Gould HP. Systematic Review of Complications Associated With Proximal Hamstring Tendon Repair. Sage Journals [Internet]. 2023 Sep 26 [cited 2025 Oct 14]; Available from: https://journals.sagepub.com/doi/10.1177/23259671231199092
19. Reito A, Manninen M, Karjalainen T. The Effect of Delay to Surgery on Major Complications after Primary Flexor Tendon Repair. The Journal of Hand Surgery (Asian-Pacific Volume) [Internet]. 2019 Apr 29 [cited 2025 Oct 14]; Available from: https://www.worldscientific.com/worldscinet/jhs
20. Hong CK, Chang CJ, Kuan FC, Hsu KL, Chen Y, Chiang CH, et al. Patients With Diabetes Mellitus Have a Higher Risk of Tendon Retear After Arthroscopic Rotator Cuff Repair: A Meta-analysis. Sage Journals [Internet], 2020 Nov 5 [cited 2025 Oct 14]; Available from: https://journals.sagepub.com/doi/10.1177/2325967120961406