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The Effect of Heparin Injection Into Cut Ends of Flexor Tendon Zone II Injuries

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ABSTRACT

Background: Because the FDP (flexor digitorum profundus) and the two slips of the FDS (flexor digitorum superficialis) are crowded within a tight fibro-osseous tunnel, it has never been easy to have good functional results after flexor tendon restoration in zone II, elevating the possibility of postoperative adhesions and a decrease in post-operative range of motion and power. Main aims of tendon repair are improved tendon healing and adhesion reduction. Primary flexor tendon healing methods are still being refined to this day.

Aim of the Work: The goal is to assess the outcomes of heparin injection into cut ends of flexor tendon zone II injuries both clinically and radiologically using musculoskeletal ultrasound.

Patients and Methods: This is an interventional clinical trial including forty individuals with flexor tendon injuries zone II. The Patients were sampled randomly into two groups, group I twenty patients (study group) with heparin injection and group II twenty patients (control group) without heparin injection.

Results: Forty cases were included in our study which had zone II flexor tendon injury repaired using four strand techniques. Both groups had the same protocol of physiotherapy and follow-up. Results were measured as regards the total range of motion according to Strickland criteria showing no significant change between the two groups. Heparin injection shows a higher rupture rate of flexor tendons which were injected also showing gap formation in MSK US. Also, heparin injection increases the formation of granulation tissue which negatively affects the gliding of tendon. So, heparin injection is not recommended in flexor tendon repair zone II.

Conclusion: Heparin injection shows a higher rupture rate of flexor tendons which were injected also which reflect gap formation in MSK US. Also, heparin injection increases the formation of adhesive granulation tissue which negatively affects the gliding of tendon.

So, heparin injection is not recommended in flexor tendon repair zone II. However, there were a few limitations to our study such as poor compliance of some patients which is considered one of the major problems that affect the post-operative outcomes.

Key Words: *Heparin – Flexor tendon – Zone II – Tendon rupture – Musculo skeletal ultrasound.*

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The study was approved by the Ethical Committee of Ain Shams University.

INTRODUCTION

Flexor tendon reconstruction, particularly zone II, are a difficult challenge for both surgeons and patients for a variety of reasons. Main reason is that injuries of these tendons need surgical repair. Also, they need careful post-operative early physiotherapy to decrease adhesions and improve gliding which carry risk of early tendon rupture **[1]**.

Despite improvement in suture materials and surgical techniques **[4]** and early post-operative controlled physiotherapy **[5]**, Tendon rupture is still one of the most difficult problems that surgeons must deal with after surgery., which usually occurs within the first 3 weeks **[2,6]**.

Post-operative physiotherapy is mandatory to achieve complete restoration of tendon function. Early motion of repair has been recommended to improve tensile strength and decrease adhesions **[9]**. Peck **[10]** Commenced early active motion at 4 to 5 days if appropriate by place and hold maneuver.

Heparin has been proven in numerous studies to have anti-inflammatory and immunomodulating characters. The etiologies of heparin's anti-

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inflammatory effects had been illustrated. **[11]**. Heparinase inhibition and adhesive molecule inhibition are two of the mechanisms involved in leukocyte recruitment into tissues **[12]**. Heparin has anti-allergenic, anti-histaminic, anti-serotonin, analgesic, and anti-proteolytic characters **[13]**. Heparin's analgesic action could be related to its ability to block pro-inflammatory chemicals that act on nerve endings **[13,14]**.

In their systematic review, Oremus and colleagues **[15]** mentioned that further studies into heparin's healing properties are highly recommended. A systematic trial regarding the effectiveness of heparin as anti-inflammatory substances in treatment of many health problems reported by Mousavi and colleagues **[16]**.

Musculo skeletal ultrasound (MSK US) plays a role in evaluating post-operative adhesions and detecting if tendon is freely mobile or not. Also, it can describe surrounding granuloma or granulation tissue which will affect the determination of post-operative rehabilitation protocols. Ultrasound is a simple and inexpensive method of research. **[17]**.

Aim of work:

The goal is to evaluate the effects of injecting heparin into the cut ends of the flexor tendon zone II injuries both clinically and radiologically using musculoskeletal ultrasound.

PATIENTS AND METHODS

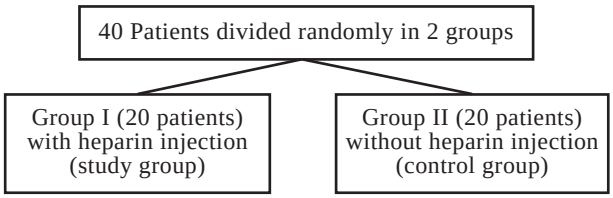
Patients: This interventional trial targeted acute zone II flexor tendon injury patients admitted and followed-up for six weeks at outpatient clinic

All patients gave written informed permission outlining the entire method under investigation in this study, and total secrecy about the patients' identities and addresses was given extra care and attention.

Type of study: This is an interventional single blinded controlled clinical trial.

Inclusion and exclusion criteria:

40 patients included in our study with acute flexor tendon injury zone II with age range between 16-40 years of both genders presented with less than 48 hours from the trauma. Medically fit with no association of any contraindications of heparin use (e.g., known hypersensitivity, coagulopathy, platelet count <100,000/mm^3, ulcerative gastrointestinal lesions, active bleeding, sever hypertension, patients receiving heparin for thromboprophylaxis, mentally disabled or comatose patients, patients with liver or renal failure, intubated and/or mechanically ventilated patients and pregnant women), not associated with extensor tendon injury, hand fractures, vascular injury or segmental tendon loss. Patients were divided into 2 groups randomly where group I (study group) with heparin injection and group II (control group) without heparin injection.



Patient underwent plain X-ray “AP, lateral, oblique views “to exclude any skeletal fracture, joint dislocations, or foreign body on admission. Also, MSK US was used in all patients post operatively for assessment of tendon gap, gliding and associated granulation tissue at 7th day and 6th week.

Methods:

Operative management:

The surgical approach: All cases were operated on by the same surgeon, only FDP was repaired. After sterilization, toweling and arm tourniquet application, exploration of tendon injuries was done. After proper positioning, the wound was extended 2 to 3cm proximally and distally in mid lateral or zig zag incisions (Bruner's approach). Injection of 0.25cc of heparin 0.5cm entry into each of tendon's cut end, 10 minutes later primary tendon repair was started in group A. Repair of tendon was done using prolene 3/0 or 4/0 by 4 strand technique supplemented with a 5-0 or 6-0 prolene epitendinous suture.

Finally, skin suturing using 4/0 prolene strand simple sutures was done. A post-operative splint was used where wrist joint is at neutral position, the inter-phalangeal joints are fully extended, and the metacarpophalangeal joints are in 90º flexion.

Post-operative protocol: All patients were discharged the next day after surgery after being instructed to visit the clinic twice weekly for the first two weeks, then once weekly until the follow-up period was completed. Post-operative medications were prescribed (Antibiotics, Anti edematous measurements, and analgesic). Passive digital motion began the first week to provide ideal passive

free mobility prior to early active protocol. Once the edema had decreased, patients were instructed to begin early active mobilization in the manner of ten repetitions hourly of midrange active flexion and extension in a splint, with the range of flexion gradually increased during the first three weeks. In follow-up visits to our OPC, healing of sutured wounds was examined. While still applying the splint, patients were guided to gradually improve their motion ranges. In most cases, skin stitches were not removed until the second week to avoid skin dehiscence during active movements. The splint was removed after the sixth week, loading exercises and light everyday activities were permitted. After three months, resistant "strengthening" activities and complete hand usage were permitted.

Regarding the radiological outcomes using MSK US, it had been demonstrated that:

The gliding of tendon was impaired in group I in (31%) compared to group II (13.8%), Table (9).

Gap formation was statistically significantly higher in heparin injection group (27.6%) compared to controlled group (3.4%), Table (10).

Granulation tissue was higher in heparin injected group (31%) compared to control group (13.8%), Table (11).

Evaluation of study: All patients were assessed to determine degree of flexion and tendon rupture rate clinically and radiologically using Musculo skeletal ultrasound.

The range of motion of the fingers was measured at the first and sixth weeks after surgery, by detecting total active movement (TAM), as per the original Strickland system. Shown in Table (1).

Demographics of patients:

Figures given in Table (3) reveal the demographic characters of the patients in both groups in this study:

Statistical analysis: The information was gathered, edited, coded, and entered a database IBM SPSS (Statistical Package for Social Science) version 23. The mean, standard deviations, and ranges were used to depict quantitative data having a parametric distribution. Qualitative variables were also provided as percentages and figures.

To compare the qualitative data between the groups, The Chi-square test was used to determine the results. An independent *t*-test was used to compare two independent groups with quantitative data and parametric distribution. A paired *t*-test was used to compare two matched groups with quantitative data and parametric distribution.

The margin of error accepted was set at 5% and the confidence interval was set to 95%. So, *p*-value was judged as following: *p*-values >0.05 are considered nonsignificant (NS), *p*-value <0.05 are considered significant (S), and *p*-values <0.01 are considered highly significant (HS).

Table (1): Strickland evaluation system **[19]**.

Score	Original Strickland (TAM / 175) (%)	TAM (PIP + DIP flexion minus extensor loss) (degree)
Excellent	85-100	>150
Good	70-84	125-149
Fair	50-69	90-124
Poor	<50	<90

Table (2): Sensitivity, specificity, and accuracy of MSK US **[20]**.

	Sensitivity	Specificity	Accuracy
MSK US	93.3%	97.8%	95.8%

Table (3): Demographic characters of both groups.

Variable	Total cases (n=40)	
	No.	%
Age:		
Adolescent (16-19 years)	8	20
Adult (20-40 years)	32	80
Gender:		
Male	36	90
Female	4	10
Dominant hand:		
Right	36	90
Left	4	10
Occupation:		
Manual worker	36	90
Others	4	10
Education:		
Low or intermediate	35	87.5
High	5	12.5
Special habits of medical importance:		
Smoking	25	62.5
Addiction	5	12.5

Table (4): Injury related details in our study.

Variables	N	Total cases	
		No.	%
Mechanism:			
Knife	40	30	75.0
Glass		4	10.0
Sharp instrument		6	15.0
Aetiology of injury:			
Accidental	40	10	25.0
Assault		30	75.0
Side of injury:			
Right	40	17	42.5
Left		23	57.5
Digital distribution:			
Thumb	52	6	11.54
Index		18	34.62
Middle		14	26.92
Ring		8	15.38
Little		6	11.54

RESULTS

As shown in Table (5), 27.6% rupture rate in group I and 3.4% in group II. The overall recovery of range of motion was 72.4% in group I and 96.6% in group II.

The mean values of TAM (Total Active Movement) measured according to Strickland evaluation, there was no statistically significant difference between both groups after 1st week and 6th, but there is significant improvement in TAM from 1 to 6 weeks post-operative weeks with the *p*-value = 0.462 and 0.407 respectively.

Table (5): Rupture rate among both groups (number of tendons in each group is 29).

Outcome	Group I N=29		Group II N=29		Chi-square test	
	No.	%	No.	%	X^2	*p*-value
Rupture	8	27.6	1	3.4	6.444	0.011
Recovery	21	72.4	28	96.6		

Table (6): TAM of repaired digits at 1 and 6 weeks in both groups.

TAM	Group I	Group II	Independent *t*-test	
			Test value	*p*-value
After 1st week	272.10±60.87	284.5±66.57	0.7403	0.462
After 6 weeks	403.22±91.03	424.07±98.67	0.8364	0.407
Paired *t*-test	5.125	5.624		
p-value	<0.001	<0.001		

Table (7): In the first week, the results of ROM in both groups were evaluated using the Strickland system. (Number of digits evaluated in each group is 26).

ROM	1st weeks Group I		1st weeks Group II		Chi-square test	
	No.	%	No.	%	X^2	*p*-value
Excellent	5	19.23	7	26.92	6.865	0.076
Good	9	34.62	14	53.85		
Fair	4	15.38	4	15.38		
Poor	8	30.77	1	3.85		

Table (8): ROM in both groups in the 6th week (Number of digits evaluated in each group is 26).

ROM	6th weeks Group I		6th weeks Group II		Chi-square test	
	No.	%	No.	%	X^2	*p*-value
Excellent	6	23.07	7	26.92	6.807	0.078
Good	11	42.31	17	65.38		
Fair	1	3.85	1	3.85		
Poor	8	30.77	1	3.85		

Table (9): Comparison between both groups according to gliding (number of tendons in each group is 29).

Gliding	Group I N=29		Group II N=29		Chi-square test	
	No.	%	No.	%	X^2	*p*-value
Normal	20	69.0	25	86.2	2.479	0.115
Impaired	9	31.0	4	13.8		

Table (10): Comparison between both groups according to gap formation (number of tendons in each group is 29).

GAP	Group I N=29		Group II N=29		Chi-square test	
	No.	%	No.	%	X^2	*p*-value
Negative	21	72.4	28	96.6	6.444	0.011
Positive	8	27.6	1	3.4		

Table (11): Comparison between both groups according to granulation tissue (number of tendons in each group is 29).

Granulation tissue	Group I N=29		Group II N=29		Chi-square test	
	No.	%	No.	%	X^2	*p*-value
Normal	20	69.0	25	86.2	2.479	0.0115
Extensive	9	31.0	4	13.8		

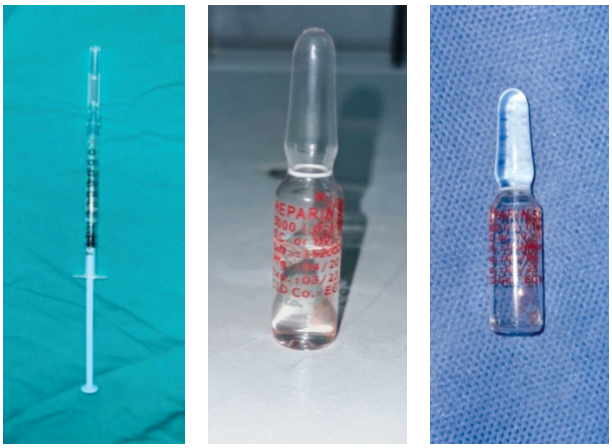


Fig. (1): Heparin insulin syringe just prior to injection.

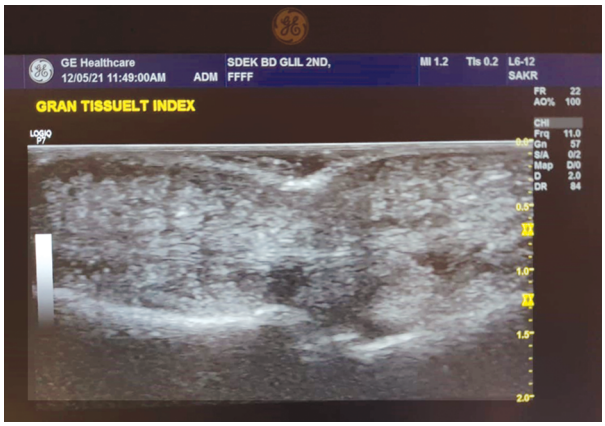


Fig. (2): MSK US shows granulation tissue formation.

Example of the clinical outcome of the patients:

Fig. (3): Restoring the normal cascade after 4 strand repair of tendon.

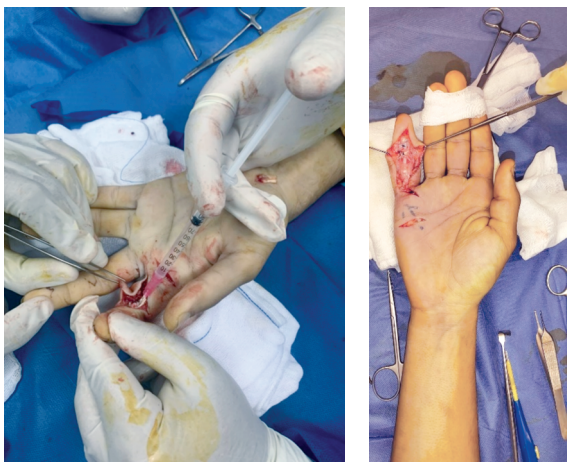


Fig. (4): Intra operative photos (first for heparin injection for patient in case group), (second photo is for another patient after tendon repair).

DISCUSSION

Studying flexor tendon surgery can be hard due to the numerous diverse ways of evaluation and categorization utilized in this field. Despite the efforts of several authors, no universally accepted treatment for flexor tendon injuries has evolved. Tendon surgery is to provide tendon healing with adequate tensile strength, adhesion reduction, proper tendon gliding and excursion **[22]**. Our Patients were treated with primary repair utilizing the 4-strand approach in this study. The early active motion technique was used for rehabilitation, and the results were delivered using the original Strickland evaluation system. That is comparable to Starnes et al., **[24]**.

Our sample consisted of 40 patients (58 tendons) ranging between 16-40 years. Predominance of young male category is noticed. This can be explained by the fact that this category is more liable to injury.

Non-highly educated individuals (87.5%) and manual workers (90%) were the most common categories of patients in this study. We can conclude that these figures are socially dependent and can be explained by the fact that they are more exposed to work-related injuries, as described by Starnes et al., **[24]** who stated that non-university graduates made up 62% of his patients while manual workers made up only 29%.

Knife was the leading causal agent in this study in terms of causative agents (75%). Starnes et al., **[24]** described a figure that is quite similar to this one (knife caused 61.1% of cases).

As regards the commonly affected digits, index and middle fingers were the most implicated fin-

gers. The fact that these fingers are frequently more exposed while undertaking industrial activities, which is the primary employment of our patients, may account for the distribution of injured fingers.

In this study, the effect of heparin injection on the range of motion and rupture rate after zone II flexor tendon repair was evaluated clinically. The tendon gap, gliding and associated granulation tissue were assessed radiologically using musculoskeletal ultrasound (MSK US). It had been demonstrated that gap formation was statistically significantly higher in heparin injection group (27.6%) compared to controlled group (3.4%). The gliding of tendon as there is impaired in group I in (31%) compared to group II (13.8%). Granulation tissue was higher in heparin injected group which was extensive in (31%) compared to control group (13.8%).

In the study of El Deek et al., **[20]**, USG (ultrasonography) detected a tendon tear in 10 of the 12 instances (83.3%). In acute cases, tendons with hematoma were discovered to be disjointed **[21]**. Claimed that ultrasound is effective in assessing tendons, with high sensitivity, specificity, and overall accuracy in detecting tendon injuries.

Only FDP (Flexor Digitorum Profundus) tendons injuries were sutured. While in this study, non-repairing injured FDS tendons was preferred to avoid adhesion with repaired FDP tendons, particularly under the narrow tunnel of the A2 pulley (zone II C), which cannot be completely vented, and due to the difficulty of repairing a thin sheet like the FDS tendon close to its insertion at zones II A and B. This study is comparable to that of Al-Qattan **[27]** who suggested FDP tendon repair only because he employed bulky core suture in his research. This opinion is to some extent also supported by Tang **[28]** who recommended only FDP tendon repair in zone II C.

In our study, rupture rate was statistically significantly higher in heparin injected group by (27.6%) while in control group the rupture rate was (3.4%).

From the first to the sixth weeks following surgery, there was a significant rise in TAM (Total Active Movement) and Strickland score, indicating the need of continuing the follow-up and rehabilitation programme to follow the progress in ROM. More research with a longer follow-up period may be required to evaluate if a more significant rise in ROM can be accomplished.

In this study, ROM in study group in 1st week was excellent to good at about 55% of the involved digits and fair to poor at about 45% of the involved digits. ROM in control group was excellent to good at about 81% of the involved digits and fair to poor at about 19% of the involved digits.

ROM in study group in 6th week was excellent to good at about 65.5% of the involved digits and fair to poor at about 34.5% of the involved digits. ROM in control group was excellent to good at about 92.5% of the involved digits and fair to poor at about 7.5% of the involved digits. Starnes et al., **[24]** had the greatest (excellent to good at 95%, no poor or fair outcomes, but one rupture digit) and worst (excellent to good at 46%, fair to poor at 64%) results, respectively.

In the study of Masoud et al., **[31]**, It was discovered that improved post-operative outcomes in the heparin-injected-group patients, as opposed to the control-group, were translated into a shorter hospital stay in the form of reduced pain and antibiotic dose. A shorter hospital stay equals a faster return to work. It not only helps the patient reintegrate into society faster, but it also helps the hospital management by lowering bed occupancy and therefore freeing up beds for other patients. Antibiotics were necessary for 2-3 weeks in 45 percent of patients in the heparin group (with an average of 9 days in the group), but 60 percent of patients in the control group (with an average of 14 days in the group) required antibiotics for the same duration.

Naniwadekar et al., **[14]** discussed that Heparin therapy reduced inflammation, prevented cellular damage, was neoangiogenic, controlled tissue repair, sped up and facilitated healing, and resulted in smooth healing, according to the study.

Ultrasound is a well-established, safe, efficient, and cost-effective tool for evaluating finger structures **[20]**. The ability to scan the finger accurately and effectively requires a thorough understanding of anatomy and technique. Ultrasound's dynamic capabilities are particularly useful for assessing tendon and pulley injury and disease with excellent sensitivity and specificity **[21]**.

Conclusion:

Heparin injection shows a higher rupture rate of flexor tendons which were injected also which reflect gap formation in MSK US. Also, heparin injection increases the formation of adhesive granulation tissue which negatively affects the gliding of tendon.

So, heparin injection is not recommended in flexor tendon repair zone II. However, there were a few limitations to our study such as poor compliance of some patients which is considered one of the major problems that affect the post-operative outcomes.

REFERENCES

1- Griffin M., Hindocha S., Jordan D., Saleh M. and Khan W.: An Overview of the Management of Flexor Tendon Injuries. The Open Orthopaedics Journal, Suppl (1): 6; 28, 2012.

2- Sadek A.F., Hweidi A.S. and Ahmed M.A.: Outcomes of staged reconstruction of Zone 2 flexor tendon injuries in recent wide-awake surgical settings and an earlier case series. Journal of Hand Surgery (European Volume), 17531934211053267, 2021.

3- Giesen T. and Elliot D.: Avoidance of unfavourable results following primary flexor tendon surgery. Indian Journal of Plastic Surgery, 46 (02): 312-324, 2013.

4- UslU M., Isik C., Ozsahin M., Ozkan A.R.İ. F., Yasar M., Orhan Z. and Sarman H.: Flexor tendons repair: Effect of core sutures caliber with increased number of suture strands and peripheral sutures. A sheep model. Orthopaedics & Traumatology: Surgery & Research, 100 (6): 611-616, 2014.

5- Frueh F.S., Kunz V.S., Gravestock I.J., Held L., Haefeli M., Giovanoli P. and Calcagni M.: Primary flexor tendon repair in zones 1 and 2: Early passive mobilization versus controlled active motion. The Journal of Hand Surgery, 39 (7): 1344-1350, 2014.

6- Thomopoulos S., Kim H.M., Das R., Silva M.J., Sakiyama-elbert S., Amiel D. and Gelberman R.H.: The effects of exogenous basic fibroblast growth factor on intrasynovial flexor tendon healing in a canine model. The Journal of Bone and Joint Surgery. American Volume, 92 (13): 2285, 2010.

7- McDonald E., Gordon J.A., Buckley J.M. and Gordon L.: Comparison of a new multifilament stainless steel suture with frequently used sutures for flexor tendon repair. The Journal of Hand Surgery, 36 (6): 1028-1034, 2011.

8- Tang J.B., Zhang Y., Cao Y. and Xie R.G.: Core suture purchase affects strength of tendon repairs. The Journal of Hand Surgery, 30 (6): 1262-1266, 2005.

9- Wada A., Kubota H., Miyanishi K., Hatanaka H., Miura H. and Iwamoto Y.: Comparison of postoperative early active mobilization and immobilization in vivo utilising a four-strand flexor tendon repair. Journal of Hand Surgery, 26 (4): 301-306. 2001.

10- Peck F.H.: Customizing flexor rehabilitation based on zone or type of injury. Tendon Surgery of the Hand. Philadelphia, Elsevier Saunders, 415-26, 2012.

11- Akbari H., Rahimi A.A.K., Ghavami Y., Mousavi S.J. and Fatemi M.J.: Effect of heparin on post-operative adhesion in flexor tendon surgery of the hand. Journal of Hand and Microsurgery, 7 (02): 244-249, 2015.

12- Page C.: Heparin and related drugs: Beyond anticoagulant activity. International Scholarly Research Notices, pp. 2013, 2013.

13- Gupta A., Verghese T.J., Gupta P. and Gupta A.K.: Role of topical heparin in the management of burns: Experience in a district government hospital of Karnataka in South India. Plastic and Aesthetic Research, 2: 111-114, 2015.

14- Manzoor S., Khan F.A., Muhammad S., Qayyum R., Muhammad I., Nazir U. and Bashir M.M.: Comparative study of conventional and topical heparin treatment in second degree burn patients for burn analgesia and wound healing. Burns, 45 (2): 379-386, 2019.

15- Oremus M., Hanson M.D., Whitlock R., Young E., Archer C., Dal Cin A. and Raina P.: A systematic review of heparin to treat burn injury. Journal of Burn Care & Research, 28 (6): 794-804, 2007.

16- Mousavi S., Moradi M., Khorshid Ahmad T. and Motamedi M.: Anti-inflammatory effects of heparin and its derivatives: A systematic review. Advances in Pharmacological Sciences, pp. 2015, 2015.

17- Georgiou A., Singh P. and Mosahebi A.: Significance of Ultrasound-Guided Approach to the Operative Repair of Zone 2 Flexor Tendon Injuries. Plastic and Reconstructive Surgery, 147 (4): 719e-721e, 2021.

18- Goggins T., Syme D. and Murali S.R. (iv): Acute flexor tendon injury and rehabilitation of hand injuries. Orthopaedics and Trauma, 28 (4): 219-224, 2014.

19- Strickland J.W. and Glogovac S.V.: Digital function following flexor tendon repair in zone II: A comparison of immobilization and controlled passive motion techniques. The Journal of Hand Surgery, 5 (6): 537-543, 1980.

20- El-Deek A.M.F. and Hassan Dawood E.M.A.EH.: Role of ultrasonography in evaluation of tendons abnormalities in hand and fingers. Egypt J. Radiol. Nucl. Med., 50 (1): 108-119, 2019.

21- Hodgson R.J., O'connor P.J. and Grainger A.J.: Tendon and ligament imaging. The British Journal of Radiology, 85 (1016): 1157-1172, 2012.

22- Unsal S.S., Yildirim T. and Armangil M.: Comparison of surgical trends in zone 2 flexor tendon repair between Turkish and international surgeons. Acta Orthopaedica et Traumatologica Turcica, 53 (6): 474-477, 2019.

23- Strickland J.W.: Development of flexor tendon surgery: Twenty-five years of progress. Journal of Hand Surgery, 25 (2): 214-235, 2000.

24- Starnes T., Saunders R.J. and Means Jr., K.R.: Clinical outcomes of zone II flexor tendon repair depending on mechanism of injury. The Journal of Hand Surgery, 37 (12): 2532-2540, 2012.

25- Sandow M.J. and Mcmahon M.: Active mobilisation following single cross grasp four-strand flexor tenorrhaphy (Adelaide repair). Journal of Hand Surgery (European Volume), 36 (6): 467-475, 2011.

26- Higgins A., Lalonde D.H., Bell M., Mckee D. and Lalonde J.F.: Avoiding flexor tendon repair rupture with intraoperative total active movement examination. Plastic and Reconstructive Surgery, 126 (3): 941-945, 2010.

27- Al-Qattan M.M.: Zone 2 lacerations of both flexor tendons of all fingers in the same patient. Journal of Hand Surgery (European Volume), 36 (3): 205-209, 2011.

28- Tang J.B.: Flexor tendon repair in zone 2C. The Journal of Hand Surgery: British & European Volume, 19 (1): 72-75, 1994.

29- Elliot D., Moiemen N.S., Flemming A.F.S., Harris S.B. and Foster A.J.: The rupture rate of acute flexor tendon repairs mobilized by the controlled active motion regimen. Journal of Hand Surgery, 19 (5): 607-612, 1994.

30- Chesney A., Chauhan A., Kattan A., Farrokhyar F. and Thoma A.: Systematic review of flexor tendon rehabilitation protocols in zone II of the hand. Plastic and Reconstructive Surgery, 127 (4): 1583-1592, 2011.

31- Masoud M., Wani A.H. and Darzi M.A.: Topical heparin versus conventional treatment in acute burns: A comparative study. Indian Journal of Burns, 22 (1): 43, 2014.