

Original Research Article

Reliability of combination of hyaluronic acid application and early rehabilitation in prevention of postoperative adhesions after primary tendon repair

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ABSTRACT

Background: The aim of the study was to evaluate the efficacy of hyaluronic acid application after tendon repair in prevention of postoperative adhesions, and to clarify the best circumstances that must be fulfilled to obtain this goal. Tissue adhesion usually happens due to injury, foreign-body reaction, bleeding, or infection but is considered an important factor for wound healing. As a result, tendons repair after injury is usually complicated due to limited postoperative movement. Several methods were used to try to prevent postoperative adhesions but most of them did not give satisfactory results as the mechanism of adhesion formation is still unclear.

Methods: Fifty patients were included in this prospective study performed at department of plastic, reconstruction and burn surgery, faculty of medicine, Menoufia University over the period of approximately two years (January 2016 to November 2017).

Results: Close follow up of the function of the repaired tendons was evaluated repeatedly over the period of 6 months. 40 patients showed excellent progress in regaining function with less possibility of performing adhesions, these patients also expressed satisfaction and comfort toward the regained function. 10 patients showed reasonable progress and were mildly satisfied.

Conclusions: Application of hyaluronic acid in addition to a well-planned rehabilitation plan is a good and reliable method against adhesions when performing primary tendon repair.

Keywords: Adhesions, Hyaluronic, Tendon

INTRODUCTION

Tendon injuries are very common in industrial and farming communities, and most of these communities' members who are affected usually suffer a lot if they don't receive proper treatment and rehabilitation financially and psychologically.¹

After surgical repair, the finger motion is usually affected by edema, then later it could be affected by adhesions between the tendon and sheath or other tissues due to

excessive scar formation.² So, in order to decrease these negative outcomes, authors must set a properly balanced regimen between protection and mobilization. As early postoperative mobilization may contribute to tendon rupture and gap formations, while late mobilization may favor adhesion formation.³ It has been known after a few experimental studies, that tendon healing pathway has a complex pattern, beginning with inflammation and cellular proliferation, followed by tissue formation and maturation with each phase lasting for variant periods of time till completed.⁴

What happens in the damaged area is that the injury stimulates an acute inflammatory reaction with the secretion of cytokines, reactive oxygen species, cationic peptides and proteases. Cell proliferation, collagen and matrix deposition and tissue remodeling follows acute inflammation, which finally results in adhesions and scar tissue formation that can partially restore tendon function.⁵

Umeda et al, demonstrated that the properties of the adhesive tissues formed around the tendon differed whether the tendon was positioned in subcutaneous tissue outside the tendon sheath, or on the damaged bony floor outside the tendon sheath.⁶ The adhesive scar in the former was formed by long, coarse fibrous elements (loose adhesion), while, the scar in latter was formed by dense fibrous elements (dense adhesion).

Hyaluronic acid importance in healing process arises from the biological benefits gained from its presence in normal loco motor system and in abnormal injury conditions. Actually, hyaluronic acid is actively secreted by tendon sheath, and is an essential component of synovial fluid of joints. This will allow smooth gliding of the tendons inside their sheaths and provides them nutrition.⁷ The biological activities of hyaluronic acid are very complex. It inhibits matrix metalloproteinases (MMPs) and the phagocytic activity of macrophages and leukocytes, it promotes the release of prostaglandins and the production of tissue inhibitor of MMP-1 and favors the normalization of native hyaluronan synthesis, it acts as free radicals scavenger and stimulates proteoglycans synthesis by chondrocytes and finally, it is provided of protective effects on chondrocytes or cartilage explants from degradation by enzymes.⁸

Several clinical and experimental studies have shown that early viscosupplementation therapy with hyaluronic acid is safe and effective in prevention of adhesions after tendon repair, especially when performed with early rehabilitation programs.⁹ So, authors performed this study to evaluate the efficacy of hyaluronic acid application after tendon repair in prevention of postoperative adhesions, and to specify the best circumstances that must be fulfilled to obtain this goal.

METHODS

This is a prospective study which was performed between January 2016 till November 2017 at plastic surgery department, Menoufia university hospital and GAMA general hospital, Saudi Arabia. The study included 50 patients of different ages undergoing immediate primary tendon repair after injury.

Preoperative management

At first, detailed history was taken to record any medical problems such as diabetes mellitus, hypertension. General and local examinations were done to evaluate all the hand

functions, ranges of motion and sensations in order to detect the affected cut tendons and any other associated injuries in the muscles, nerves and blood vessels. Routine laboratory investigations including complete blood count, kidney and liver enzymes, random blood sugar, prothrombin time and ratio, hepatitis B, C markers and chest X-ray were performed to complete evaluation of general condition of patients. A detailed consent concerning operative procedure was taken, in addition to taking standard photos for the injury and the affected tendons preoperatively, intra and postoperatively.

All relevant ethical aspects were considered in conducting the research. The participants were assured that their participation in the study is voluntary and that they can withdraw at any time; confidentiality and privacy of the participants were respected. Also, informed consents were taken from the patients declaring their will to participate in the study. For patients under the age of 18, informed consent was taken from their parents, but the data of the questionnaire was collected from the patient.

Operative procedure

The patient was operated under local or general anesthesia according to the severity and number of tendons affected. The patient was operated in the supine position. Opening of the affected wound and exploration of the injured tendons was done, then the proximal and distal ends of the affected tendons were evaluated carefully to see if primary repair is to be done or concern other options. If the proximal and distal ends had no serious damage or lacerations with the ability to meet each other without marked tension, primary repair was done. Primary repair was performed using modified Kessler or Bunnell sutures according to the nature of injury and the condition of proximal and distal ends (Figure 1a). But, before the repair was done, authors would add hyaluronic acid to both edges of the repair. And after performing the repair, authors added a considerable amount of hyaluronic acid around the repair site and 1 to 3 cm proximal and distal to it (Figure 1b, 1c and Figure 2). The type of hyaluronic acid (HA) used was the high molecular weight-based type dissolved in saline with the ratio of 1 ml HA: 3 ml saline, in order to break any cross-links present. This was followed by meticulous closure of the wound to end the operation.

Postoperative procedures

The patient's hand was put in rest position for 3 to 4 days. And sutures were removed after 7 to 10 days. Authors began an early rehabilitation program on the 5th day, in which light passive mobilization was begun on the basis of 2 groups of motion daily, each group included 15 passive movements for the period of 3 weeks. Followed by heavy passive mobilization on the basis of 5 groups of motion, each group included 15 passive movements for the period of 3 weeks. And at last, active mobilization

was performed on the basis of 4 groups of motion, each group included 20 active movements for the period of 8 weeks with no serious overload on the repaired tendons.

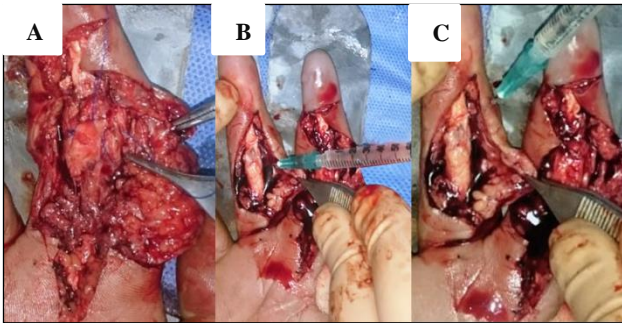


Figure 1: Primary tendons repair for a 35 years old female patient with injury to the flexor digitorum profundus tendons of the right index and middle finger and ring fingers, zone II, (A) during performing primary repair of the index finger tendon, (B) during injection of hyaluronic acid after performing primary repair of middle finger tendon (proximal injection), (C) during injection of hyaluronic acid after performing primary repair of middle finger tendon (distal injection).

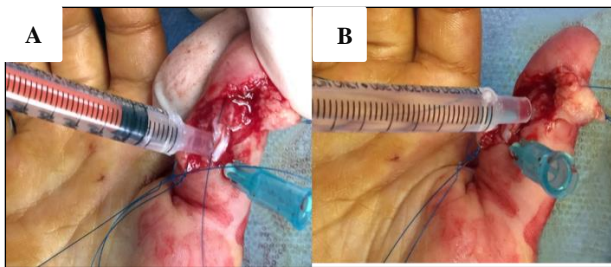


Figure 2: Primary tendon repair for a 4 years old male patient with injury to the right flexor pollicis longus tendon of the right thumb, zone II, (A) during injection of hyaluronic acid after performing primary repair of tendon (proximal injection), (b) during injection of hyaluronic acid after performing primary repair of tendon (distal injection).

Follow up

The patients were warned not to uplift any heavy weights for at least one year after repair. And the total hand function was evaluated after 4 and 6 months of the performed repair.

Statistical analysis

Chi-square and fisher exact test were used for comparison of qualitative variables. Authors used one-way ANOVA test to compare between means of categorical and numerical data. Significance level (p value) was adopted, i.e. $p < 0.05$ for interpretation of results of tests of significance.

RESULTS

This study included fifty patients, all did primary tendon repair after injury. Their age ranged from 6 to 56 years (mean value 31.2 years), 39 of these patients were above age of 15 years (26 males and 13 females), and 11 were below age of 15 years (7 males and 4 females) (Table 1).

Table 1: Age and genders of the participating patients.

Age (in years)	Males	Females	Total
Above 15	26	13	39
Below 15	7	4	11
Total	33	17	50

About 41 patients were performed under general anesthesia and 9 patients were under local anesthesia. All patients had hyaluronic acid applied to the site of repair and began early rehabilitation after repair.

After 4 months follow up, 34 (87.1%) patients above age of 15 and 7 (63.6%) patients below age of 15, with the total number of 41 (82%) patients, showed excellent progress in regaining normal active function with less possibility of performing dense adhesions, these patients also declared satisfaction and comfort toward the regained function expressing a significant p value ($p < 0.05$). On the other hand, 5 (12.9%) patients above the age of 15 and 4 (36.4%) patients below the age of 15, with the total number of 9 (18%) patients, showed reasonable to poor progress in regaining normal active function and were mildly to poorly satisfied.

After 6 months follow up, there was regression in the improvement gained after 4 months in 1 (-9.1%) patient below the age of 15 from excellent progress to poor progress with the possibility of dense adhesions formation. Making the result: 40 (80%) patients showing excellent progress in regaining normal active function with less possibility of performing dense adhesions, and 10 (20%) patients showing reasonable to poor progress in regaining normal active function (Table 2).

Table 2: Relation between the ages of patients and patients' progress after 4 and 6 months.

Age (in years)	Above age of 15	Below age of 15	Total
Good progress after 4 months	34	7	41
Bad progress after 4 months	5	4	9
Good progress after 6 months	34	6	40
Bad progress after 6 months	5	5	10

Complications following were: (a) 5 patients had wound infection: they were treated by proper dressing and antibiotic, the wounds healed after with no need for secondary sutures, (b) 1 patient showed sudden loss of function due to improper repair: revision of the repair was done immediately on diagnosis and the patient improved properly after.

DISCUSSION

Peritendinous adhesions after repair of any tendon injury is a serious problem in hand surgery. The adhesions are a part of the healing process that may produce functional disability.¹⁰

Weeks and Wray have classified the adhesions into two categories: one is a loose adhesion that is performed by the aid of subsequent physical therapy to increase gliding, and the other is dense adhesions that prevent gliding.¹¹

HA is a polysaccharide found in the synovial fluid. It has been suggested to play a possible role during the early stages of healing of a variety of connective tissues, including injured tendon. So, it has been extensively studied as a guard against dense adhesions formation in digits as some investigations suggested that HA promotes tendon healing and decreases dense adhesion formation.^{12,13}

In this study, authors found out that injection of hyaluronic acid during primary repair prevented in most cases the formation of dense adhesions that causes functional disability. This was concurred by Asaka et al who injected high molecular weight hyaluronic acid around the flexor tendons of a canine model, concluding that hyaluronic acid diminishes the excursion resistance after flexor tendon repair.¹⁴

Authors also chose to use high molecular weight hyaluronic acid for application around the repaired tendon for its high long term gliding effect, this was also concurred by Ozgenel et al who investigated the efficacy of high molecular HA injections versus placebo (saline) on functional outcomes after zone II flexor tendon repair.² Hyaluronic acid was given around the tenorrhaphy site, and a rehabilitation program was started on the 3rd postoperative day. Range of motion (active and passive) and functional outcome (Strickland classification) were assessed. Within 3 weeks period, no difference between the two groups was observed; however, after 3 months a significant increase in the total values of the passive and active range of motion was present in fingers treated with HA. Noteworthy, no adverse events (signs of inflammation or tendon rupture) were seen in any cases.

Similarly, in a multicenter randomized controlled trial, Hyaloglide, which is a thick and sticky gel that adheres to the surface of the tendon, was applied after flexor tenolysis in Zone II following flexor tendon repair.¹ Patients in the

study group, compared with not treated controls, showed a greater total active motion and finger function, with an earlier return to work and daily activities. Noteworthy, Hyaloglide did not affect tendon and wound healing and did not increase the complications rate.

Looking for the causes of unfavorable results obtained by this study, it was found among patients who did not stick properly to the early rehabilitation program, allowing dense adhesions to be formed and decrease the gliding power of hyaluronic acid added. The study performed by Percival et al also concludes the same and stresses on the importance of proper rehabilitation after tendon repair. These unfavorable results were found more between children as they could not apply the precise details of the rehabilitation program properly.¹⁵

CONCLUSION

From the results obtained in this study, authors could conclude that application of hyaluronic acid during performing tendon repair in addition to an early well-planned rehabilitation plan is a good and reliable method against allowing formation of dense adhesions that would disturb regaining active normal mobility.

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Conflict of interest: None declared

Ethical approval: The study was approved by the Institutional Ethics Committee of Menoufia University-Faculty of Medicine

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