Lengthening of the flexor tendons by autogenic extensor tendon and ear cartilage grafts
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Abstract
The aim of this study was to evaluate the efficacy of lengthening the superficial digital flexor tendon after resecting part from it by an autogenus graft from extensor tendon and ear cartilage in rabbits. This was conducted on twelve animals. The animals were inspected clinically and biopsies were taken from the grafts and the normal tendon at 15 and 30 post operative days. Clinical examination of experimental animals and the patch grafts showed no apparent abnormalities and occurrence of simple bulge site of operation in animal treated with ear cartilage. Histopathological examination showed extensive formation of dense connective tissue in animals treated with ear cartilage with invasion of cartilage by connective tissue was seen at 30 post operative day in comparison with the group treated with extensor tendon. Faster formation of granulation tissue with presence of tendon tissue similar to original tendon were seen in animals treated with extensor tendon grafts at 30 post operative day.

Introduction
Tendon lengthening is often used to treat many injuries in the tendon such as tendon laceration and rupture which are common among large animals and give rise to a clinical situation that excludes the animal from work and exercise (1-3). Also tendon lengthening needs to be improved in condition such as tendon ossification, flexed tendon, tumors, strain, and chronic tendosynovitis (4-7). For this reason autogenic, allogenic, heterogenic or xenograft and artificial tendon transplantation have been performed with varying degree of success. Muscle, fascia and plastic material also were used as substitutes for tendon (7-13). On the other hand in reconstructive surgery cartilage has been used as a biological material for a long period of time (6). It is used as supporting tissue in ears, nostrils, to fill depression in bone and for rapier of osteochondral defect. The nature of cartilage provide flexibility with support to the transplanted tissue, does not shrink and can be confide into any shape and so it may be sterilized and kept for a considerable time (13-16). Moreover, it can be used fresh or preserved, allogenous, autologus, homologus and also heterologus from the ear, rib and nasal septum (6,17,18). From a review of the literature it become evident that the use of ear cartilage for tendon lengthening have never been attempted both in humans or animals. There for, the goal of the present study was to use ear cartilage as autogenic graft for tendon lengthening experimentally.

Materials and Methods
In this study the common digital extensor tendon from the fore left limb and ear cartilage were collected from the same animal (rabbit) at the time of surgery, the two tissue were rinsed in a sterile physiological saline solution at 4°C, the fascia and perichondrium around the tendon and cartilage respectively were completely removed, then the two tissues were preserved in sterile saline solution at 4°C until using it for transplantation. The length of the all graft were approximately 2.5cm and the width of the ear cartilage was 3-4 mm. Twelve mature local rabbits from both sexes were used. The protocol of anesthesia was a mixture of Xylazine ketamin at the doses of (15,45 mg /kg I.M) respectively. The right hind leg was prepared for an aseptic surgical intervention. The skin was incised on the lateral part of distal third of the tibia over the tendon, the fascia and tendon sheath were incised. About 2.5
cm of superficial flexor tendon (S.F.T.) were resected. Then the animals were divided into two groups as following:

Group 1: The common digital extensor tendon replaced the superficial flexor tendon and sutured with the tendon stumps of (S.F.T.) by No.3-0 silk using a single locking loop suture pattern (Fig: 1-A) (7).

Group 2: The ear cartilage was used to replace the superficial flexor tendon according to lange method (Fig.1) with using No 3-0 silk (Fig:1-B) (5).

The operated leg was bandaged after operation and the rabbits were kept in restricted area individually to limit their movement. They received penicillin streptomycin antibiotic at adose of 10,000 I.U. and 10 mg/kg B.W. respectively for five days. After seven days the bandage was removed and the rabbits had freedom of movement (7). The operative animals inspected daily and postoperatively mentioned for 30 days.

Tissue specimens were harvested from the original tendon and the grafts at 15 and 30 days following operation. The process was performed aseptically following general anesthesia. Tissue specimens were fixed in 10% formalin solution for 48 hrs, trimmed to suitable size dehydrated, cleared in xylol, embedded in paraffin wax, sectioned at 5-6 \( \mu \) thickness, stained with hematoxylin and eosin and examined with light microscope (19).

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**Fig.1:**

A- A extensor tendon graft used to lengthen a flexor tendon incorporating the single locking loop suture pattern (7).

B- A cartilage graft used to lengthen a flexor tendon incorporating the lange method (5).
Results

Results of the clinical study revealed slight redness and swelling of the site of operation in group 1 and this swelling disappeared within 5-7 (mean 6±0.5) days after operation , while in group 2 moderate redness and edema occurred around the site of operation and lasted for 7-10 ( mean 8.5±17.5) days , after that the animals retained gradually to normal condition.The rabbits were clinically lame severly for 1-3 days post operation , dragging the affected leg and not putting weight on it . Later , however ,the animals used their legs slightly and the condition improved after 10±0.01 days in group 1 and 13-15 (mean 14±0.8)days in group 2 . The bandage was removed on the 7th day in order to improve their exercise while they were kept in small restricted cages to prevent violent movement . There was no wound infection in the two groups during biopsy collection. Adhesion between the grafts and the surrounding tissue was present specially in animals grafted with cartilage. Further more , the area of repair in group 2 was more bulky.The main histopathological changes in animals transplanted with extensor tendon at 15 days post operation were formation of vascularized fibrous tissue consisting of fibroblasts and collagen fibers. This tissue was visualized bridging between the two types of tendon . Infiltration of mononuclear cells was also seen in the normal tendon and transplanted tendon at the site of transplantation (Fig.2) . At 30 days post operation infiltration of inflammatory mononuclear cells was seen in the transplanted tendon and also suture material was visualized in some of the sections and this was surrounded by connective tissue and inflammatory cells mainly the polymorphnuclear cells. At some sections the two ends of tendon stump were united with each other by formation of new tendenous tissue and in some sections mature granulation tissue was seen in between the two types of tendons , dense bundles of collagen fibers were visualized also (Fig.3).In animals transplanted with cartilage at 15 days post operation infiltration of mononuclear cells ( plasma cells, macrophage and lymphocytes) was seen in between the two types of tissue(cartilage and tendon),also vascularized fibrous tissue consisting of fibroblasts and collagen fibers was visualized bridging between the two types of tissue .Connective tissue capsule was seen around the cartilage markedly (Fig.4). At 30 day postoperation the main histopathological finding was invasion of connective tissue capsule into cartilage was seen in some sections , infiltration of mononuclear cells and well vascularized connective tissue formation were observed (Fig. 5) .
Fig. 2: Histopathologic structure of transplanted extensor tendon in group 1 showing granulation tissue formation (G) at 15 days after transplantation. H&E. X65.

Fig. 3: Histopathologic structure of transplanted extensor tendon in group 1 at 30 days after transplantation (a) showing extensor tendon (ET), (b) flexor tendon (FT) and infiltration of leukocytes. H&E. X100.
Discussion

Clinically, the redness and edema of the operative site in all of the experimental animals could be attributed to trauma inflicted on the tissue during surgery. Following trauma inflammation occurs leading to hyperemia and edema (20). Similar to the process of wound healing in other parts of the body tendon healing begins with an inflammatory reaction (21). Both extrinsic and intrinsic components can be involved in tendon healing. Because the tendon was previously considered as inert almost a vascular structure with low repair potential, healing was by growth of fibroblasts and capillaries from periteninous tissue (15,21). The local inflammatory changes (edema and redness) of the site of operation.
disappeared within 5-7 days in animals transplanted with superficial digital extensor tendon and within 7-10 days in animals transplanted with cartilage. The difference could be explained on the basis that tendon is more acceptable as graft (22). The immobilization was removed at 7 days because recently there has been interest in avoiding prolonged immobilization following operative treatment, the goals are to prevent musculoskeletal changes associated with immobilization to reduce rehabilitation time and to facilitate an early return to work and pre injury activities(23).

In animals grafted with cartilage adhesion was seen markedly during biopsy collection, this change could be attributed to formation of connective tissue around the graft this adhesion that develops is part of the healing process(24).

The present results clearly showed that the thickness of the connective tissue capsule around the cartilage was more dense in comparison with tendon. A thick capsule around cartilage would permit better fixation of this graft to the tendon, this may be due to the fact that cartilage possesses many advantages in relation to other types of grafted material, this is due to not only to its anatomic shape, thickness and elasticity, but also to its structure, which prevents stronger immunologic reactions, namely cartilage cell (chondrocytes) are located in special cavities(lacunae) in the bulky mass and the extra cellular matrix, which is a barrier for immune active cells and also filter for antibodies (25).

Additionally cartilage does not possess its own blood vessels, being nourished by diffusion from its surroundings. All the above-mentioned facts give it the attribute of a good implant, especially because a connective tissue capsule is formed around cartilaginous implants in all living beings (18). From the clinical and histopathological results of this study it could be concluded that using of autogenic cartilage graft for reconstruction of severed tendon damage in clinical cases could be helpful especially when the availability of autogenous tendon is limited.

References


تطويل الأوتار المثنية برقاع ذاتية من الأوتار الباسطة وغضروف الإذن

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الخلاصة

الهدف من هذا البحث هو تقييم كفاءة تطويل الوتر المثني السطحي بعد إزالة جزء منه برقع ذاتية من الوتر الباسط وغضروف الإذن. في الدراسة، تم استخدام 20 حيوانًا من الأرانب استخلصت الخزع النسيجي من مكان العملية، وتم تقسيم الورق الخاص للحيوانات في فئتين: فئة پ1 (الحيوانات مع علاج التقويم في وتر الراقبة) وفئة پ2 (الحيوانات بدون علاج التقويم في وتر الراقبة). تم تجميع نتائج الدراسة في جدول 1 و2 و3.

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يومًا بعد العملية، ظهرت تحسينات بشكل كبير في الحيوانات المعالجة بترقية غضروف الإذن، وأظهرت نسبًا تقليل كلي في البشروط المحبطة للحيوانات المعالجة، وبدأت تظهر النسب الجبيبي ووجود نسيج وثري مشابه للوثر الأصلي في الحيوانات المعالجة بترقية غضروف الإذن. في الفترة 30 يومًا بعد العملية.