

SURGICAL TREATMENT OF MUSCULUS GASTROCNEMIUS TENDON RUPTURE BY USE OF TENSOR FASCIA LATA AUTOGRAFT: AN EXPERIMENTAL STUDY ON RABBIT MODEL

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Geliş Tarihi : 24.03.2003

Summary: The aim of this study was to investigate whether the fascia lata (FL) could be used as a graft material for the repairing of large defect of m. gastrocnemius tendon. Twelve healthy adult white rabbits were included to the study. A curved skin incision about 5 cm in length was made over the lateral aspect of the cranio-lateral region of femur to harvest FL. 4x3 cm in size of FL was bluntly separated and harvested. 2 cm piece of the m. gastrocnemius tendon was cut and removed from each rabbit at the level of 1 cm proximal of tuber calcaneus under general anaesthesia. Fascia lata graft was covered around the tendon starting 1 cm both distal and proximal to the transection sites of the m. gastrocnemius tendon and sutured by locking loop suture pattern with PDS. Rabbits were evaluated up to 10 weeks for disfiguration and functional limb usage. At 10 weeks postoperatively, contrast radiographic and histological examination were carried out to reveal the survival of FL.

All rabbits showed a significant lameness following three days postoperatively but no sign of lameness were observed at the day of 15. Contrast radiographic examination indicated a satisfactory union between the implanted material and the tendon ends.

At 10 weeks, 8 of the 12 rabbits were euthanased. Remaining 4 rabbits were observed for their functional status up to one year. In gross examinations of the euthanased rabbits, the gap was filled in by a firm and smooth new tissue formation.

Microscopic examination at 10 weeks showed that the defect was filled with immature fibrous connective tissue proliferation and occasional vascularity in which collagen fibers tended to be oriented longitudinally as in mature tendon. Early co-crimping of tendon fiber bundles was apparent on longitudinal sections.

In conclusion, clinical, radiological and histopathological examinations revealed that implantation of the FL graft was a useful model of tendon healing without any complications.

Key words: Fascia lata graft, m. gastrocnemius tendon rupture, rabbit.

Gastrocnemius Tendo Rupturunun Tensor Fasya Lata Ototrefti Kullanımıyla Operatif Sağaltımı: Tavşanlarda Deneysel Bir Çalışma

Özet: Çalışmada, tensor fasya latanın m. gastrocnemius tendon rupturunda bir greft materyali olarak kullanılıp kullanılamayacağını araştırılması amaçlandı.

Çalışma 12 sağlıklı beyaz tavşan üzerinde yürütüldü. Fasya lata (FL) greftinin elde edilmesi amacıyla femurun kranio-lateral bölgesi üzerinde 5 cm uzunluğunda eliptik bir deri ensizyonu yapıldı. 4x3 cm büyüklüğünde FL kesiti greft amacıyla izole edildi. Her bir tavşandan genel anestezi eşliğinde 2 cm uzunluğunda m. gastrocnemius tendon kesiti tuber calcaneusdan 1 cm proksimal yönde olmak üzere kesilip uzaklaştırılmak suretiyle defekt oluşturuldu. Fasya lata grefti gastrocnemius tendosunun distal ve proksimal segmentinden 1 cm mesafeden başlamak üzere PDS iplikle locking loop dikiş tekniği kullanılarak kapatıldı. Tavşanlar, yaklaşık 10 hafta operasyona tabi tutulan bacağı kullanma yönündeki fonksiyonlarının tespit amacıyla gözlemlendi. Postoperatif olarak 10. haftada kontrast radyografi ve histolojik muayeneler FL'nin bütünlüğünü saptamak amacıyla yapıldı.

Tüm tavşanlar postoperatif olarak 3. günden sonra belirgin bir topallık gösterdi. 15 günde hiç bir topallık belirtisi gözlenmedi. Kontrast radyografik muayeneler tendon ve implante edilen materyal arasında başarılı bir kaynaşmanın olduğunu gösterdi. 12 tavşanın 8'i nekroskopik ve mikroskopik muayene için uyutulurken, diğer 4 tavşan ise fonksiyonel yürüyüş durumlarını gözlemek için bir yıl gözetim altında tutuldu. Nekroskopide, m. gastrocnemius tendosunda oluşturulan defektin yumuşak yeni bir doku tarafından doldurulduğu görüldü. 10. haftada yapılan mikroskopik muayeneler defektin immature konnektif doku üremesiyle dolduğu ve olgun tendodakine benzer longitudinal bir yapı arzettiği saptandı. Tendon fibril demetlerinin erken ko-krimping özelliği longitudinal yönde alınan örneklerde barizdi.

Sonuç olarak, klinik, radyolojik ve histopatolojik incelemeler FL greft implantasyonunun tendon iyileşmesinde faydalı bir model olduğunu ortaya çıkardı.

Anahtar Sözcükler: Fasya lata grefti, m. gastrocnemius rupturu, tavşan.

INTRODUCTION

The main component of the common calcaneal tendon is the gastrocnemius tendon. It origins in two portion as lateral and medial¹⁻³.

Muscles and tendon injuries are recognized as an

important cause of lameness in domestic animals³⁻⁷. Depending on the level of injury proximal to the hock, the superficial digital flexor or gastrocnemius tendon is more superficial and more readily severed^{3,7,8}. When both structures are completely disrupted, the hock has no support and drops markedly. Rupture of only the gastrocnemius tendon allows the hock to flex

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and drop, and the animal walks with some difficulty^{3,8,9}.

Surgical treatment is usually advisable in order to protect the severely injured or ruptured tendon from the normal disruptive stress occurring by weight bearing and to gain normal tendon function^{3,6-8,10,11}.

Various techniques for the repair of tendon laceration or rupture have been described in human being and animal. Primary suturing of the tendon ends with a Bunnel or locking loop suture pattern are most common^{6,12-15}. Furthermore, the tendon injuries may be repaired by transposition of the tendon of the peroneus longus muscle¹⁶, by fascia lata¹⁷ (FL), carbon fiber implants¹⁸⁻²⁰, by fibrin gluing^{21,22}, by tendon transplantation²³⁻²⁶, by homologous artery graft²⁷, and cast application²⁸.

Previously FL was successfully used to repair various tissue injuries in human and animal including large abdominal defect²⁹, joint surface defect³⁰, retinal detachments³¹, and reconstruction of diaphragm defect³². As a source of donor tissue, it was used to treat chronic superficial digital tendon injuries in a dog without any histological examination¹⁷. Furthermore, it has been used in human for the treatment of tendon lacerations³³ but, its use in animals is limited by availability.

The aim of this study was:

- 1- To investigate whether FL could be used as a graft material for the repairing of large defect of m. gastrocnemius tendon.
- 2- To reveal survival of the FL and gap filling status by a new tissue formation histologically.
- 3- To investigate any adhesion formation between m. gastrocnemius tendon and the surrounding components.

MATERIALS and METHODS

Animals: Twelve healthy adult white rabbits between 11 to 13 months in age, 2.3 to 2.7 kg in body weight and both sex groups were included into the study.

Anaesthesia Protocols: Each of the rabbit was fasted 12 hours prior to the operation. For the induction of anaesthesia, the rabbits were sedated with xylazine hydrochlorur (Rompun 2%, Bayer) as a dose of 5 mg/kg of body weight intramuscularly. Following 10 minutes of premedication, general anaesthesia was induced by the intramuscular route administration of

ketamine hydrochlorur (Ketalar, Parke-Davis) as a dose of 25 mg/kg or body weight and anaesthesia maintained by intermittent half doses of ketamine as required.

Surgical Procedures

Preparation of Fascia Lata: Each of the rabbits was positioned in left lateral recumbency. The area to be exposed were clipped and prepared for aseptic surgery.

A curved skin incision approximately 5 cm in length was made over the lateral aspect of femur to harvest the FL graft. The subcutaneous tissues were dissected to expose the FL. Approximately 4x3 cm of FL was bluntly separated and harvested. The harvested piece of the FL was preserved in a sterile gauze impregnated with 0.9% NaCl solution. The rest of the FL in the body was sutured to the facial edge of the biceps femoris muscle using 4-0 polyglactin (Vicryl; Ethicon) suture. The skin was then closed by simple interrupted suture.

Creation of Defect on M. Gastrocnemius Tendon and Transplantation of Fascia Lata: The rabbits were placed in sternal position for producing tendon defect and FL transplantation. A 5-cm skin incision starting from just 1 cm proximal to the tuber calcanei was made. The subcutaneous tissues were bluntly dissected to isolate the m. gastrocnemius tendon and a 2-cm piece of it then transversally cut and removed (Fig 1a). Fascia lata graft was covered around the tendon starting 1 cm both distal and proximal to the transaction sites of the m. gastrocnemius tendon (Fig 1b) and sutured by locking loop suture pattern using 4-0 polydioxanone (PDS, Ethicon). The fascial transplant was then sutured to the tendon in a circumferential manner by a continuous pattern (Fig 1c). The subcutaneous tissues and skin were closed separately by simple interrupted suture of 3-0 polyglactin 910 (Vicryl, Ethicon).

Postoperative Care and Examinations: The wound was wrapped with sterile gauze and the leg was bandaged with polyvinyl chloride (PVC) in its neutral position. Postoperatively the rabbits were received procaine penicillin (40.000 IU/kg body weight) for 5 days intramuscularly. Bandages were changed every three days and removed at 15 days postoperatively. Rabbits were confined to a small room for 10 weeks and evaluated every three days during the bandage changing for signs of pain, palpable swelling, disfiguration and functional limb usage. At 10 weeks postoperatively, each of the rabbits was anaesthetised for contrast radiographic

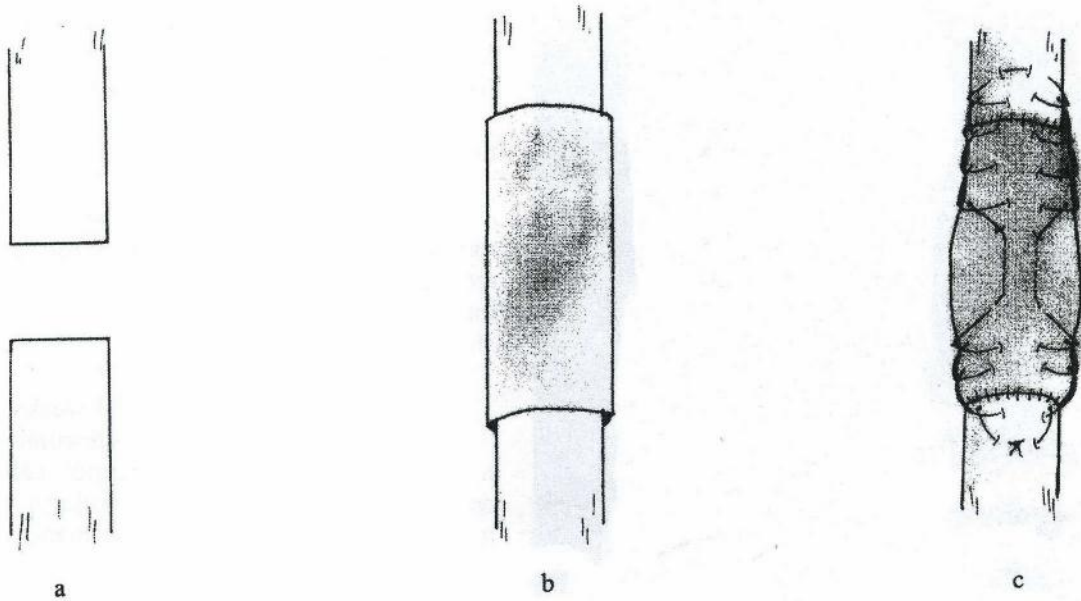


Figure 1. Schematic illustration of the FL grafting. Transected site of m. gastrocnemius tendon (2 cm removed portion) between the cut ends (a), the gastrocnemius tendon encased by FL (b), locking loop suture pattern and the edge of the FL was sutured to the tendon with a simple continuous pattern (c).

Resim1. Fasya lata implantasyonunun şematik görünümü. M. gastrocnemius tendosunun 2 cm'lik bir kısmının kesilmesi (a), FL ile defekt oluşturulan kısmın sarılması (b), FL ile tendonun locking loop dikiş tekniği kullanılarak dikilmesi.

examination as described. Therefore, 5 ml sodium and maglumine ioxithalamate (Télébrix 35; Guerbet, France) was injected nearby the m. gastrocnemius tendon and a latero medial x-ray film taken.

Macroscopic and Histopathological Examination: Eight of the 12 rabbits were euthanased at 10 weeks postoperatively by an overdose of sodium pentobarbital (40 mg/kg). Gross observation of those rabbits was made including the status and surface contour of the FL and the availability of any adhesion formation. A tendon parts including fused tendon ends with FL was removed and fixed in the buffered formalin. The specimens were cut longitudinally and transversally, embedded in paraffin and stained with hematoxylin and eosin. Histological examinations mainly consisted of the survival of the FL and the status of the gap filling.

Remaining 4 rabbits were monitored for functional limb usage and any lameness up to one year.

RESULTS

Accessing and dissecting of the FL were found to be easy. Following the suturing, the strength between the FL and m. gastrocnemius tendon was also found to be quite strong.

All rabbits showed a significant lameness following

three days postoperatively at the time of bandage removal. The same but less severe lameness was noted at day 6. At 9 days, they used their legs tentatively. At the day of 12 postoperatively, only three rabbits were noted to have a slight lameness. At the day of 15, no sign of lameness were observed for any of the rabbits. The surgical wounds were healed at the day of 10 and no sign of wound infection was noted for the all rabbit. There was some palpable thickening over the side of implanted FL for 4 rabbits. No degenerative and reparative responses were observed in any of the implanted rabbits. During the manual extension and flexion of the tarsal joint at 10 week postoperatively, no laxity and any other abnormalities were recorded.

Contrast radiographic examination indicated that there was a satisfactory union between the implanted material and the tendon ends. The gap between tendon ends was observed to be filled by soft tissue densities. There was also a normal tract of the contrast agent through m. gastrocnemius tendon (Fig. 2).

In gross examination, all surgical sites had healed by primary intention. A good union between the implanted material and the stumps of the m. gastrocnemius tendon was observed for all animals. The gap was filled in by a firm and smooth new tissue

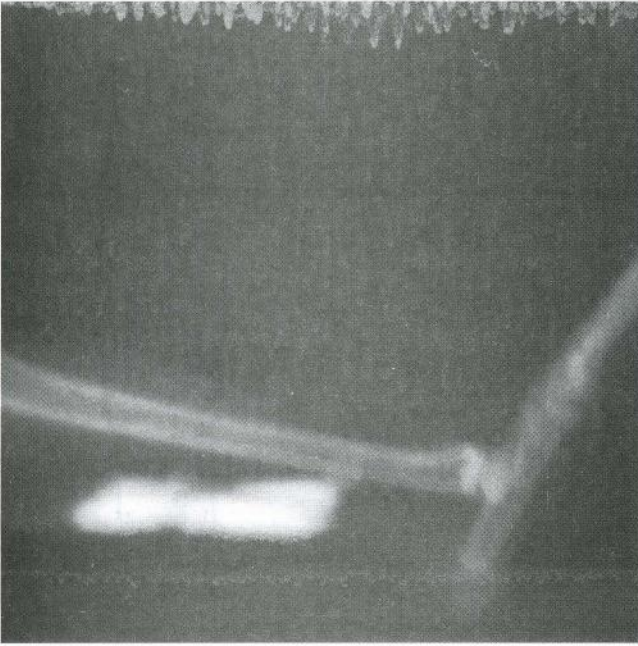


Figure 2. Contrast radiography of the m. gastrocnemius tendon 10 weeks after the grafting. There is a normal tract of the contrast agent through the m. gastrocnemius tendon.

Resim 2. Implantasyondan 10 hafta sonra m. gastrocnemius tendosunun kontrast radyografisi. Kontrast madde tendo boyunca düzgün ilerleme göstermiş.

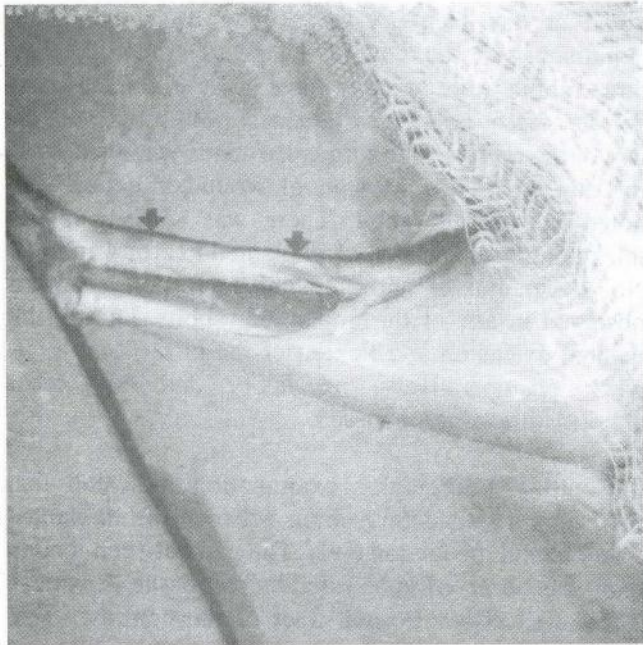


Figure 3. Gross appearance of the m. gastrocnemius tendon 10 weeks after the surgery. The transacted tendon ends were filled with a new tissue formation (arrow).

Resim 3. M. gastrocnemiusun makroskopik görünümü. Defekt oluşturulan tendon kısmının yumuşak dokuyla dolmuş hali (oklar).

formation (Fig 3). However, there was some degree of oedema containing gelatinous tissue formation and redness over the new tissue in 4 rabbits and therefore, the new tissue was a little thickness. No signs of adherence between the new tissue and the surrounding tissues were detected.

At the final clinical examination of the remaining 4 rabbits following 12 months postoperatively, the reconstructed area upon the gastrocnemius tendon was intact and continuous and no lameness or any other abnormalities were observed.

Microscopic examination at 10 weeks showed that the defect was filled with immature connective fibrous tissue proliferation of moderate cellularity and occasional vascularity in which collagen fibers tended to be oriented longitudinally as in mature tendon (Fig. 4). The nuclei of the plump fibroblasts were larger with no mitoses. Early co-crimping of tendon fiber bundles indicating elastin formation was apparent on longitudinal sections (Fig. 5). Cellular inflammatory response was minimal in tissues not in direct contact with peripheric paratenon suture. Occasionally, foreign body reactions limited to the granulation tissue around the PDS sutures were present. These filaments were surrounded by a few fibroblasts, lymphocytes, plasma cells and foamy macrophages. Foreign body giant cells were observed infrequently.

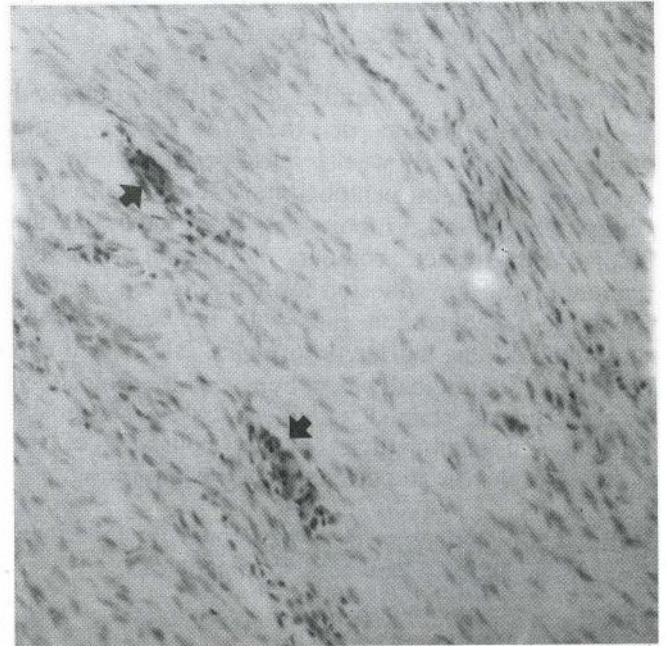


Figure 4. The tendon repair site shows moderate cellularity and vascularity (arrows). Collagen fibers and plump fibroblasts are partially arranged longitudinally (HEX200).

Resim 4. Onarılan tendon bölgesinde orta derecede hücresel infiltrasyon ve damarsal oluşum (oklar). Kollajen fibriller ve fibroblastların longitudinal olarak şekillendiği görülüyor.



Figure 5. Longitudinal section of the tendon repair site. The tissue filling the gap is mature and appears similar to normal tendon (below) with highly ordered collagen fibers and flat fibrocytes. No inflammations is present. Co-crimping is well established (HEX200).

Resim 5. Onarılan tendon bölgesinin longitudinal kesit bölgesi. Defekt oluşturulan kısmın olgun tendo dokusuyla dolduğu ve normal tendon dokusunun sahip olduğu şekilde fibrosit ve kollajen fibrillerini içerdiği gözleniyor. Hiçbir yangısal reaksiyon yok. Ko-krimbing oldukça gelişmiş olarak not edilmekte.

DISCUSSION

In the present study, clinical, radiological and histopathological examinations revealed that implantation of the FL graft to experimentally induce gastrocnemius defect provided a useful model of tendon healing without the additional postoperative complications associated with the surgery. At the macroscopic examinations, there was a good union between the transplants and the stumps of the tendon as the tendon has attained more tensile strength and one could not be able to distinguish where the stump end.

An ideal graft material to be used for tendon and ligament defect has been reported as it should induce collagen formation, be elastic, strong, inert, have a high tensile characteristic, suitable thickness and size and high tissue acceptability^{14,34,35}. Histopathological evaluation of the present study indicated that repair method produced a fibrovascular tissue bridge between the tendon ends and the repair was adequately strong to support weight for free exercise. Early co-crimping of tendon fiber bundles indicating elastin formation was apparent on longitudinal sections. Under the results of this study, FL implant

may be deduced as an optimal implant since it carries the characteristic of ideal graft material as reported previously.

Optimal tendon repair requires reestablishment of collagen fiber and tendon continuity. When adhesions form during healing process, gliding of the tendons is limited and function impaired^{4,36}. Adhesions restrict motion, decrease function and often lead to permanent deformation^{6-8,37,38}. Many methods have been proposed to reduce adhesions after tendon injury or surgery. Materials such as nylon, teflon, polyethylene, siliastic and natural membranes such as arter graft, periton, amniotic membrane and fascia lata have been used to form a pseudosheath to prevent fibrous adhesion ingrowths after tendon repair^{10,27,39-42}. The above mentioned method has advantages and disadvantages depending on their structural components. No sign of adhesions was found in the present study.

Tendon injuries have been repaired by transposition of either the plantaris tendon or peroneus brevis tendon¹⁶, by FL¹⁷ and carbon fiber implants¹⁸⁻²⁰, by fibrin gluing^{21,22} and by tendon transplantation²³⁻²⁵. Surgical treatment of tendon injuries has also been made in human using autograft FL³³ but its use in veterinary practice is limited by availability. Fascia lata was used to treat chronic superficial digital tendon injury in a dog previously¹⁷. However, histopathology and adaptation of the graft postoperatively was not performed. The adaptation and survival of the FL in the present study was determined histologically and there was a fibrous connective tissue proliferation between the tendon ends which can highly be preferable for the repair of the animal with severely damaged tendon that tenorrhaphy is impossible.

The methods of suturing tendons might affect their healing potential and, therefore, the clinical results^{6,12,14,43}. The locking loop suture pattern has been suggested as an effective method for suturing tendons where tension is likely during the early postoperative periods^{6,12,43}. It has the advantages of minimal interferences with tendon blood supply, of sufficient strength to prevent gap formation, of minimal damage to the epitheon, of little expose of the suture material^{12,13}. The advantages of the locking loop suture were also experienced in the present study. Fascia lata was easily implanted and knotted in a locking loop pattern. Problems with fraying, fragmentation and knot slippage were not encountered. The tendon ends were apposed well with the graft.

In conclusion, clinical, radiological and histopathological examinations revealed that implantation of the FL auto graft was a useful model

of tendon healing without any postoperative drawbacks. It was suggested that FL could be used for the tendon defect which primary end to end tenorrhaphy may not be possible because of tendon retraction and tendon damage.

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