Dept. of surgery,
Fac. Vet. Med., Assiut University,
Head of Dept. Prof. Dr. M.T. Nassef.

THE USE OF CARBON FIBER AS AN AID FOR TREATMENT OF EXPERIMENTALLY RUPTURED ACHILLES TENDON IN DOGS

(With 10 Figuers)

By

M.T. NASSEF; A.H. BAYOMI*; A.S. SALEH;
M.A. ALI and SOHAIR, Z. HAUSSIEN

(Received at 15/2/1993)

إستخدام ألياف الكربون كوسيله لعلاج القطع التجريبى لوتر أخيلس فى الكلاب

محمود منطاوى ، عبد اللطيف بيومى ، أحمد صالح
محمد عادل ، سهير زين العابدين

أجريت هذه الدراسه على عدد ٢٠ كلب حيث تم زرع ألياف الكربون بعد ازالة جزء من وتر أخيلس ولقد أظهرت النتائج الأكلينيكيه والمجهريه أن استخدام ألياف الكربون أعطت نتائج مرضيه فى التئام الوتر المقطوع فى الكلاب.

*: Dept. of Pathology, Fac. Vet. Med., Assiut University.

SUMMARY

The present study was carried out on 20 clinically healthy dogs of both sexes. After tenectomy of Achilles tendon, full thickness carbon fiber graft was created. The clinical and histopathological findings cleared that the use of carbon fiber implant appeared satisfactory for the repair of the ruptured tendon in dogs.

INTRODUCTION

Tendons are highly specialized tissues. They are the connecting apparatus of muscle and bone. Rupture of tendo-Achilles in dogs are commonly resulting from accident *(VIERHELLER, 1972)* or jumping on the rear limbs *(MILTON and HENDERSON, 1980)*.

Suturing of ruptured tendo-Achilles were performed by using a variety of natural or synthetic materials. *SKOOG and PERSON (1954)* sutured the profundos tendons in dogs with monofilament stainless steel wire. *EL-GUINDY (1970), SURGI and ADAMSON (1972), VAUGHAN (1979) and MUBIKI (1981)* used chromic catgut as suture material for Achilles tendon rupture in dogs. *LEONARD (1961), EL-GUINDY (1970) and VAUGHAN (1979)* preferred silk in cases of tendon and ligament injuries in dogs. Recently carbon fiber used for suturing tendons by *DENNY and GOODSHIP (1980), VAUGHAN (1981), STEYN (1984) and VAUGHAN (1985).*

The aim of the present study is to evaluate the use of carbon fiber for full thickness graft in the treatment of tendo-Achilles injuries in dogs. It is also aimed to study the response of the fibroblast to implanted carbon fiber.

MATERIAL and METHODS

The present study was carried out on 20 clinically healthy adult dogs of both sexes (13 males and 7 females). The ages of these animals ranged from 18-40 months and they were about 13-22 Kg.b.wt. The dogs were randomly assigned to four groups each of 5 dogs according to the time of euthenasia for taking histopathological specimens. The first, second, third and fourth groups were euthenasied at 15, 30, 60 and 90 days post-operation respectively.

Food was with held 12 hours before the operation. Each dog was premedicated by intramuscular injection of chlorpromazine HCl in a dose of 1 mg/Kg.b.wt. Surgical anaesthesia was induced by intravenous injection of thiopental sodium 5% until the main reflexes were abolished.

The operation site was prepared for aseptic operation. The dog was fixed in lateral recumbency with the upper pelvic limb unfixed (operated limb). A lateral skin incision about 6 cm long was done over the Achilles tendon. The skin was dissected from the underlying subcutaneous tissue. The paratenon was incised longitudinally. Dissection was then carried out to isolate the paratenon from the tightly attached Achilles tendon.

Carbon fiber implantation was created by passing the implant through the musculo-tendinous junction proximally and through a hole in the distal end of the tendo-Achilles near its junction with calcaneous process distally. Tenectomy was then performed by removing the central 3 cm of Achilles tendon. Fixation of carbon fiber implant was done by 2-3 stout suture using 2/0 PDS (poly-dexanon suture) at both ends of severed tendon (Fig. 1). The sutures passed transversely to encircle both carbon fiber and some of tendon tissue.

The paratenon was sutured using 2/0 PDS with simple continuous suture (Fig. 2) and the skin wound was finally closed with silk No. 0 using interrupted horizontal mattress suture. Aqueous solution of crystalline penicillin was infiltered around the operative field.

The operated limb was immobilized directly after finishing of carbon fiber implantation using plaster of paris bandage. The bandage included the foot and extended proximally to just below the stifle joint of the operated limb. Bandage and skin suture were removed after 10 days. The limb re-immobilized again for further 20 days.

Prophylactic doses of broad spectrum antibiotic were injected intramuscularly for five successive days post-operatively. The dogs were euthenasied at 15, 30, 60 and 90 days after the operation for collection of histopathological specimens. The specimens were prepared routinely and stained by haematoxylin and Eosin stain.

RESULTS

Clinical observations:

All dogs showed rigid extension of the hock joint inconvenient in the first few days after operation and immobilization. Removal of the leg bandage at the 10th day post-operatively cleared that wound healing was excellent. Healing was by 1st intention in 17 dogs (Fig. 3). These animals were able to stand normally and to bear full weight on the operated limb within one month. There was no adhesion between the skin and the underlying subcutaneous tissue and implanted carbon fiber.

The operated area was swollen, hot and painful in three dogs (Fig. 4). Healing took place by secondary intention. There was adhesion between the skin and implanted carbon fiber. These animals showed severe degree of lameness and had put full body weight on the operated limb at the 6th week.

At the time of bandage removal and by palpation at the site of carbon fiber implantation, there was slight swelling only at the proximal and distal stumps of severed tendon. The implanted carbon fiber at this stage was thinner than Achilles tendon of non operated limb. Thickening of the implanted carbon fiber was began later on till it reached the normal size of Achilles tendon by the end of the fourth week.

Palpation of the implanted carbon fiber six weeks after operation revealed its thickness then gradually decreased reacing the normal diameter in comparison with the healthy limb (at the end of the 10th week).

Histopathological examination:

Histopathologicl examination of the specimens taken from the 1st group revealed that large area of erythrocytic extravasations filled the gap between the tedinous tissue which gave great resemblance to a haematoma (Fig. 5). In the second group, the areas of haemorrhage were completely cleaned from blood constituents by lysis and phagocytosis (Fig. 6). At this stage light to moderate cellular infiltration was noticed around and near the carbon fibers (Fig. 7).

Mature connective tissue could be observed around carbon fiber 60 days post-operatively (Fig. 8). At this stage the fibrous connective tissue was longitudinally oriented. In some sections carbon fibers appeared to be fragmented into irregular lengths (Fig. 9). In the fourth group, severe fragmented carbon filaments were frequently entrapped by fibrous tissue. At last new tendineous like tissue could be noticed (Fig. 10).

DISCUSSION

Open tendon operation for full thickness carbon fiber implantation in the present work was performed successfully and healing occured in the majority of cases by first intention. This result was in contrary to that mentioned by *LITTLEWOOD (1979) and LANGLOIS (1980)* where they used carbon fiber enclosed in a plastic sheath and tunneled into the tendon without opening the skin to overcome the risk of sepsis in cases of sprained tendon and tendinitis. However, percutaneous tunneled carbon fiber into the tendon can not be used in the present study where tendo-Achilles was completely severed experimentally.

In 3 cases skin healing occured by 2nd intention because of secondary bacterial infection. Sepsis in these cases may be attributed to field infection.

Fixation of the operated limb following carbon fiber implantation is of great importance. Immobilization using plaster of paris cast post-operatively facilitaties revascularization for the tendon repair until healing process is well established. This method was used successively also by *ASHEIM (1964), BRADEN (1974), VAUGHAN & EDWARDS (1978) and SHARMA et al. (1980)*. On the other hand, *EL-GUINDY (1970) and MASRY (1988)* advised immobilization with wooden splints and padding for 10 days until skin stitches were removed and afterthen a plaster of paris cast was performed. They added that rupture of tendon sutures may take place during removal of the cast. In the present experiment, removal of the plaster cast 10 days post-operatively to take off skin stitches resulted in no cases of tendon sutures rupture. The use of chlorpromazine HCl and small dose of thiopental sodium facilitated to a great extent the process of cast removal.

In our study no complications associated with the use of carbon implants have been recorded. On the contrary, *ALEXANDER et al. (1979) and LANGLOIS (1980)* reported wound infections and draining sinus tracts.

The reaction around carbon fiber in this study represented inert foreign body fibrosis as described by *FORSTER et al. (1978) and BROWN & POOL (1983)*. The initial fibrous response that formed the scar arose probably from the peritenonium internum and externum as well as from the peritendinous loose connective tissue. We are in agreement with *JENKINS et al. (1977) and FORSTER et al. (1978)* that the fibrous tissue in healing tendon aligns itself along the direction of tensile stress.

In our study, the fibrous response resembled the tendinous tissue. This response could be attributed to the gradual mechanical failure of carbon implant which subsequently increased the tensile load on the newly formed collagen fibers causing them to mature and to orient in the direction of stress. We could conclude that carbon fiber implants are biocompatable and under ideal circumstances can serve as a scaffold for the engrowth of fibrous tissue to form a neo-ligament which can take over the function of severe tendon.

REFERENCES

Alexander, H.; Weiss, A.B. and Parsons, J.R. (1979): Ligament and tendon replacement with absorbable polymer filaments with flexible carbon tissue scaffolds. In transactions. Orthop. Res. Soc., p. 72.

Asheim, A. (1964): Surgical treatment of tendon injuries in horses. *J.A.V.M.A. 145: 446-451.*

Braden, T.D. (1974): Musculotendinous rupture of Achilles apparatus and repair using internal fixation only. Vet. Med. Small Anim. Clin., 69: 729-733.

Brown, M.P. and Pool, R.R. (1983): Experimental and clinical investigations of carbon fibre sutures in equine tendon repair. J.A.V.M.A., 182: 956-966

Denny, H.R. and Goodship, A.E. (1980): Replacement of the anterior cruciate ligament with carbon fibre in dog. J. Small Anim Pract., 21: 279-286.

El-Guindy, M.H. (1970): Experimental studies on repair of divided tendo-Achilles in dogs. The Egyptian Vet. Med. J., Fac. Vet. Med., Cairo Univ., 171: 249-257.

Forster, I.W.; Ralis, Z.A.; Mckibbin, B. and Jenkins, D.H.R. (1978): Biological reaction to carbon fiber implants: The formation and structure of a carbon induced neo-tendon. Clin. Orthop., 131: 299-307.

Jenkins, D.H.R.; Froster, I.W.; Mckibbin, B. and Ralis, Z.A. (1977): Induction of tendon and ligament formation by carbon implants. J. Bone Joint Surg., 59: 53-57.

Langlois, P. (1980): Utilsation des fibre de carbone dans Ls chirurige orthopedique du cheval. Part. Vet. Eq., 12: 73-78.

Leonard, E.P. (1961): Orthopedic surgery of the dog and cat. W.B. Saunders Company, Philadelphia and London.

Littlewood, H.F. (1979): Treatment of sprained tendons in horse with carbon fibre implants. Vet. Rec., 105: 223-244.

Masry, K.I. (1988) Healing of ruptured tendo-Achilles in goats with special reference to tendon transplantation. M.V.Sc. Thesis Vet. Surgery Fac. Vet. Med., Adfina, Alexandria University.

Mbuiki, S.M. (1981): Treatment of severed Achilles tendons in a calf and kid. Mod. Vet. Pract., 62: 786-787.

Milton, J.L. and Henderson, R. (1980): Surgery of muscles and tendons. Current techniques in small animal surgery, 2nd Ed. pp. 465-519.

Sharma, S.N.; Prasad, B. and Kohli, R.N. (1980): Surgical repair of unilateral prepubic tendon rupture in a she-buffalo. Indian Vet. J., 57: 249-250.

Skoog, T. and Person, B.H. (1954): An experimental study of early healing of tendon. Plast. Reconstr. Surg. 13: 384-386.

Srugi, S. and Adamson, J.E. (1972): A comparative study of tendon suture materials in dogs. Plast. Reconstr. Surg. 50: 31.

Steyn, D.G. (1984): The use of carbon fibre to replace the torn cranial cruciate ligament in the dog. A clinical procedure. Journal of the South African Veterinary Association, 55: 29-32.

Vaughan, L.C. and Edwards, G.B. (1978): The use of carbon fibre (Grafil) for tendon repair in animals. Vet. Rec., 102: 287-288.

Vaughan, L.C. (1979): Muscle and tendon injuries in dogs. J. Small Anim. Pract., 20: 711-736.

Vaughan, L.C. (1981): The use of carbon fibre implants for the repair of Achilles tendon rupture in dogs. J. Small Anim. Pract. 22: 629-634.

Vaughan, L.C. (1985): The management of tendons injuries in dogs. J. Small Anim. Pract. 26: 133-142.

Vierheller, R.C. (1972): Surgical repair of severed tendons and ligament in the dogs. Modern Vet. Practice 53: 35-38.

LEGEND

Fig. 1: Fixation of carbon fiber implant using 2/0 PDS suture.

Fig. 2: Partial suturing of paratenon with simple continous suture.

Fig. 3: Healing was excellent and occured by 1st intention.

Fig. 4: Healing took place by 2nd intention. Notice the operated area is swollen and inflamed.

Fig. 5: Erthrocytic extravasations in the gap between the tendinous tissue (H&E x 250).

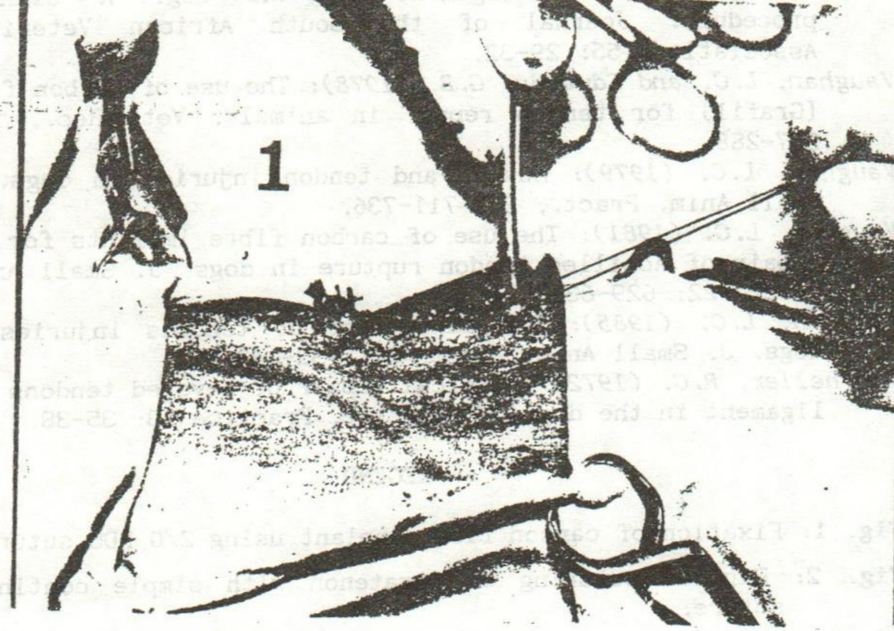
Fig. 6: Cleaning and organization of haematoma (H&E x 250).

Fig. 7: Light to moderate cellular infilrates around the carbon fibers (H&E x250).

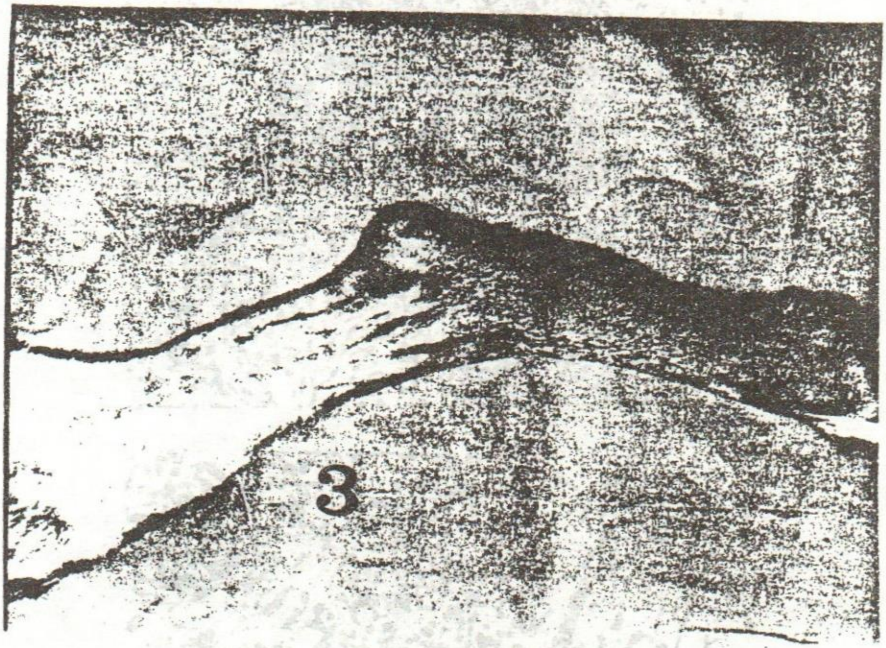
Fig. 8: Mature connective tissue oriented around the carbon fibers (H&E x100).

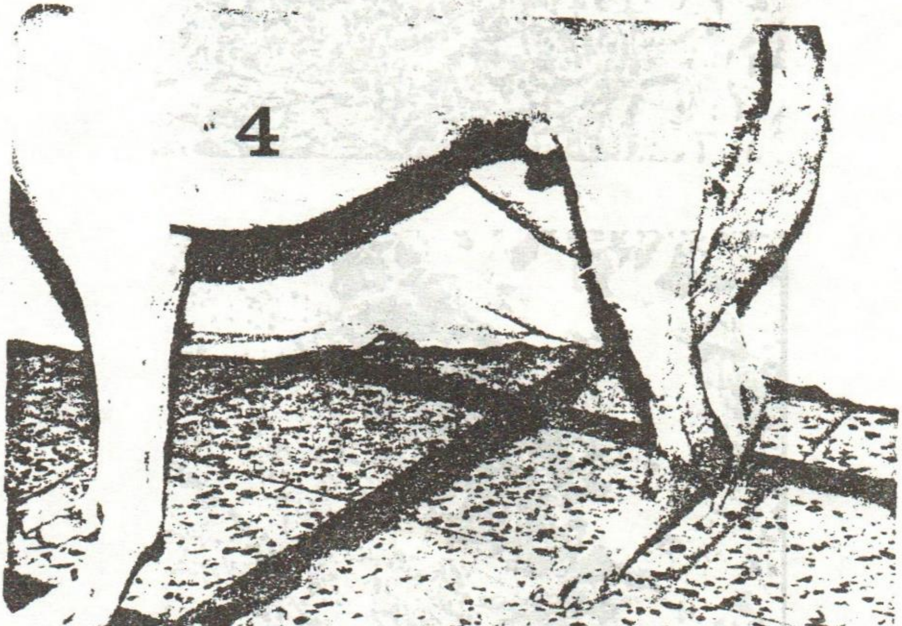
Fig. 9: Fragmented carbon fiber. Notice the separated fibers (H&E x100).

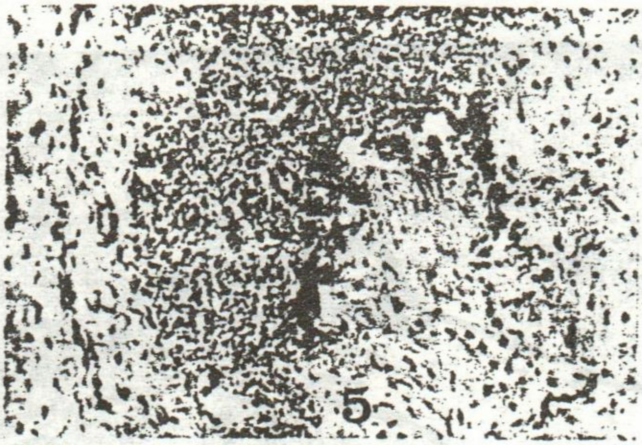
Fig.10: Fragmented and relatively separated carbon fiber. Notice the presence of new tendinous tissue (H&E x100).

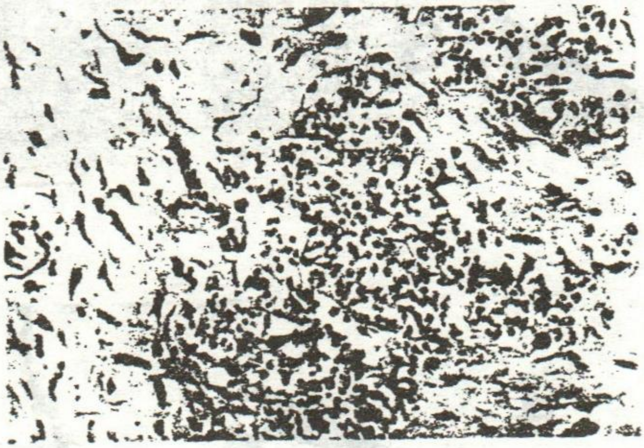

1

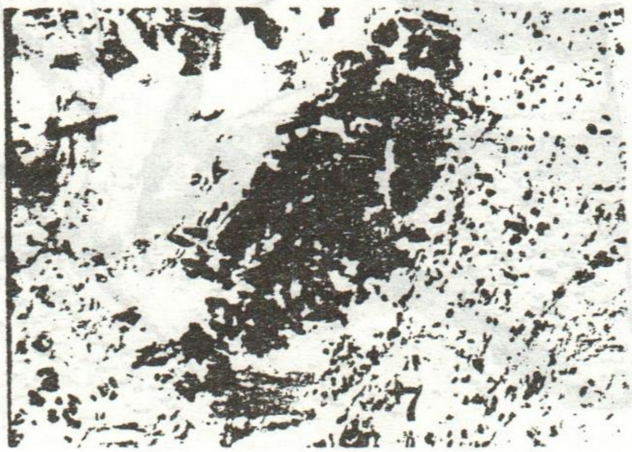

2

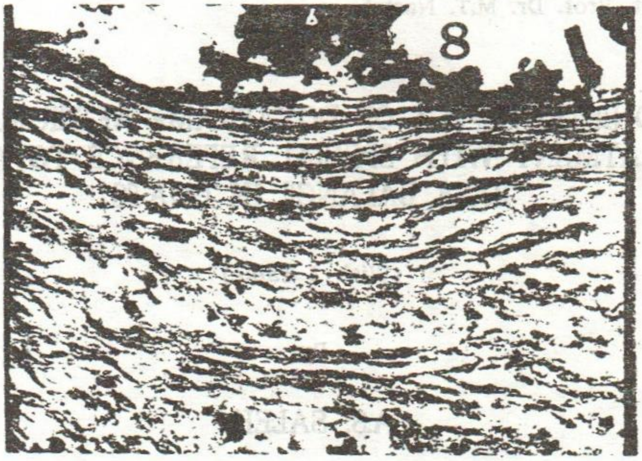




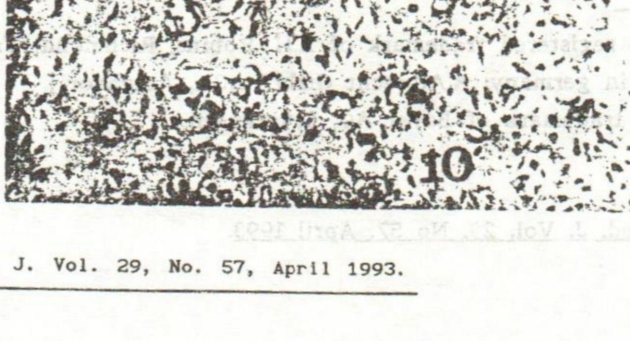

5




7


8


6


10