A comparative study of using Kessler Suture Pattern versus Polypropylene meshes implantation to repair Tenotomized Achilles tendon in bucks

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Summary

The aim of the current study was to compare the efficacy of Kessler suture pattern and polypropylene meshes implantation to repair severed Achilles tendons in bucks. For this purpos 16 local adult bucks, weighing 30-35kg were used and equally distributed into two groups, the first group: (control group) and the second group (mesh group). Animals were sedated with xylazine 2% and anesthetized locally with lidocaine hydrochloride 2% infiltrated subcutaneously. Skin incision approximately 5 cm. in length was made over the Achilles tendon. The tendon was isolated by blunt dissection from the underlying tissue, then the left Achilles tendon was transected in its mid portion. In the control group, tenorrhaphy of Achilles tendons were immediately performed by using Kessler suture technique using (polypropylene No. 1). In the second group, a polypropylene mesh was wrapped around the cut ends and fixed to the tendon by simple interrupted stitches of polypropylene thread (No.1). Then skin was sutured by interrupted horizontal mattress using silk No.1. Finally plaster of Paris with window was applied. The skin stitches were removed after 10 days. The clinical signs of all animals showed severe lameness during the first three weeks with no significant differences between the two groups. Lameness reflected significant differences ($P<0.05$) between groups with the progress of postoperative duration (i.e., starting from 4^{th} week). Rapid absence of lameness was more observed in second group (at 4^{th} week) than in first group (at 6^{th} week). At two months post-operative, a higher percentage (100%) was recorded in first group. While a lower percentage (25%) was showed in the second group. Microscopical examination at two month post-suturing revealed proliferation of fibrous connective tissue around suture materials infiltrated by inflammatory cells, in addition to necrotic tissue attachment to the tendon. In mesh implantation and at the same time there were granulations tissues surrounding the narrow mesh holes with tendon fibers expressed proliferation of tenocytes. At four months, first group revealed few blood vessels, and thickened collagen fibers with mononuclear cells infiltration in cut tendon fibers. In mesh implantation the tendon was retained to its nearly normal structure with few (MNCs) in epitenon. It seemed that both groups gave best outcome in healing of operated tendons with superiority of the second group in comparison with the first group.

Keywords: Kessler suture, Polypropylene meshes, Implantation, Achilles tendon, Bucks.

Introduction

Tendon injury is a problem requiring a repair followed by an early mobilization. However, it actually heals slowly and frequently leaves scar tissue in situ (1). The golden aim at tendon repair is to establish a permanent repair that could withstand significant tensile strength loads and to glide smoothly without any interference against movement. However, no method of treatment has proved to accelerate the rate, or improve the healing quality (2). Healing of tendon is slow and may require long period (9-12 months or more in some cases) due to its poor vascularity (3). Recently, multifactorial strategies treatments for Achilles tendon lesions are used such as application of prosthetic meshes which act as a scaffold to conduct the two cut ends of the tendon. In addition to stability of the rupture sites, they should be porous to facilitate cells migration and proliferation and movement of growth factors (4). Other treatment choices include tendon transplantation, Laser, shock wave, stem cells, platelet rich plasma, autologous conditioned plasma, autologous conditioned serum and cells therapy (5 and 6). The study aimed to compare the efficacy of Kessler

suture and polypropylene meshes implantation to repair tenotomized Achilles tendons in bucks based on clinico-pathological evaluations.

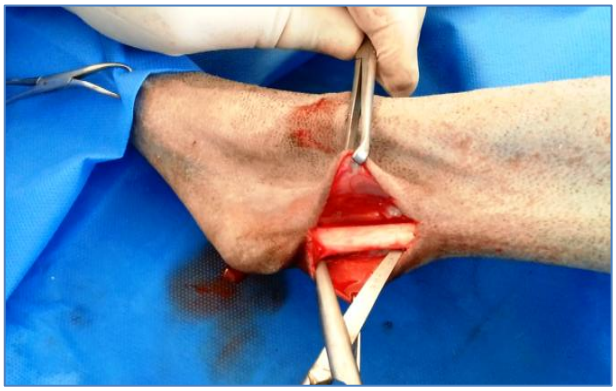
Materials and Methods

The study included 16 clinically normal local adult bucks, their ages ranged between (2-3) years and weighing 30-35 kg. The animals were equally divided into two groups. The first group serves as a control group. The second group is (polypropylene meshes). The animals were sedated with xylazine hydrochloride (2% xylo-Germany) in a dose rate of 0.5 mg/kg administered via intramuscular route. The left Achilles tendon of each buck was prepared for aseptic surgical operation and placed on right recumbency with operated limb up then anesthetized locally with lidocaine hydrochloride 2% in a dose rate of 3 mg/kg B.W., infiltrated subcutaneously above the Achilles tendon (7). Skin incision approximately 5 cm., in length was made over the Achilles tendon. The tendon was isolated from the underlying tissue by blunt dissection (Fig. 1). A full-thickness transverse incision of the left Achilles tendon was performed in its mid-portion (Fig. 2).

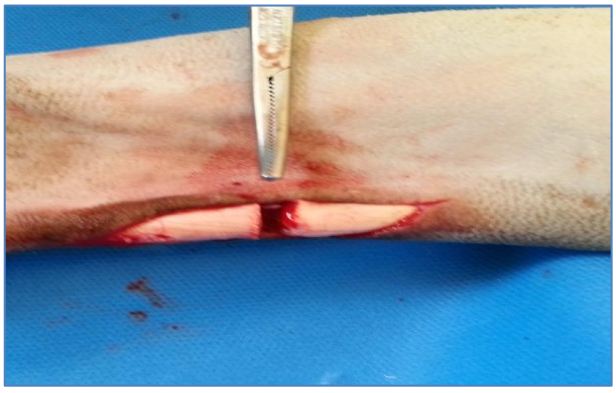
In the first group, tenorrhaphy of Achilles tendons was immediately performed by using Kessler suture technique as described by (8). The sharply cut tendon ends were approximated centrally and repaired by using (Polypropylene No.1) (Fig. 3). In the second group and after tendon suturing as mentioned in control group, a polypropylene mesh was wrapped around the cut ends and fixed to the tendon by simple interrupted stitches of polypropylene thread (No.1) (Fig. 4). After completion of suture and mesh implantation, the skin was sutured by interrupted horizontal mattress using (Silk No.1). Plaster of Paris cast extending from the stifle joint to the end of the limb was applied. A window in the cast was created at the site of skin incision. Broad spectrum antibiotic represented by pencillin-streptomycine in a dose of 10000 I.U and 5 mg/kg B.W., respectively was injected IM for five consecutive days and skin stitches were removed at 10^{th} day post operation.

The clinical evaluations consisted monitoring of the local swelling of the operated area, local heat, pain and degree of lameness as mentioned by (9). This was performed at two and four months post-operation. The repair site was visually examined to determine any changes in the tendons and the severity of peritendinous adhesions which may happen between the tendon and surrounding tissue. Adhesions were quantified into five grades (0-4) (10). Tendon biopsies ($1cm^3$) were obtained for microscopical examination which was performed at two and four months post-operative to follow tendon healing. Eight bucks were used for each group (4 bucks/ period). Biopsies were fixed in 10% neutral buffered formalin and passes routinely. Sections were cut at a thickness of 5-6 µm and stained with (H&E) (11).

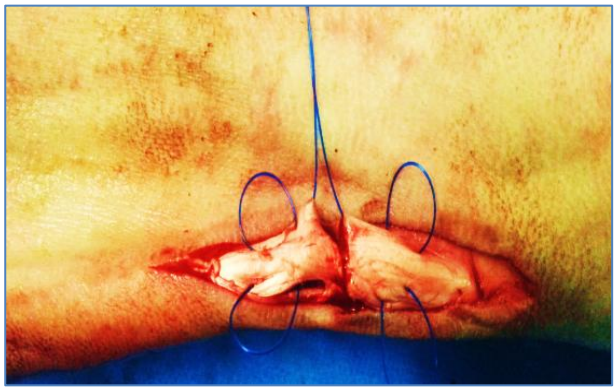
The statistical analysis was conducted by (12). All data observations were expressed as Mean±Standard Error (M±SE) and differences between the groups of animals were compared using one-way Analysis of Variance (ANOVA). Least significant difference (LSD) was used to compare between means. The level $P<0.05$ was considered to be significant.



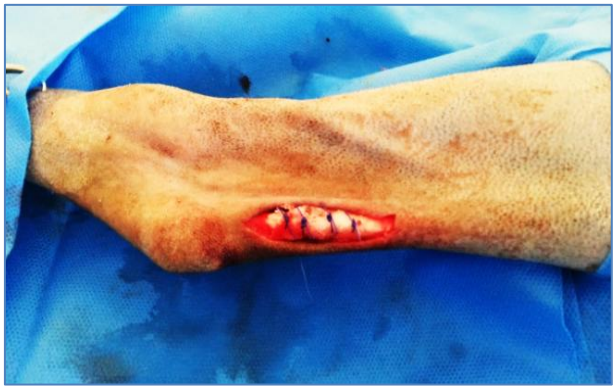
Figure, 1: Skin is incised and blunt dissection is made to separate the tendon from the surrounding structures.



Figure, 2: Achilles tendon is transected in its mid portion.



Figure, 3: Suturing Achilles tendon with Kessler pattern (two loops on each side).



Figure, 4: Polypropylene mesh is fixed to the tendon core with simple interrupted stitches of polypropylene thread.

Results and Discussion

There were no intraoperative complications. All bucks showed good general health status. There was no sign of local swelling or infection no wound dehiscence were evidence at the site of operation during the follow-up period in any of the operated animals. All skin wounds healed normally within 10 days post-surgery. After clinical follow-up all animals showed severe lameness during the week (0) with (score 4) in the first group and (score 3.5) in second group and the animals cannot bear weight on the operative limb. Furthermore lameness was prominent at 1st and 2nd weeks post-surgery with absence of significant differences between the two groups. Lameness reflected significant differences $P<0.05$ between groups with the progress of post-operative duration (i.e., starting from 3rd week). Rapid absence of lameness was noticed in mesh group at 4th week (score 0) and at 6th week in suture group (Table, 1).

During a follow-up of treatment animals there were no any serious complications (infection, failure of tendon repair or death) this may be attributed to strike aseptic technique beside good post-operative follow-up. In contrast (13) recorded seroma, fever, erythema of the operative area and wound dehiscence due to infection. Lameness noticed in the present study may be related to pain resulted from inflammation and cutting of the nerves in the operative site. A study by (14) indicated that chemical irritants and neurotransmitters may generate pain in tendinopathy due to increase in levels of lactic acid.

Table, 1: Shows the mean values of lameness scores of first and second groups.

Weeks	First group Score	Second group Score	LSD value
0	4.0	3.5	0.026 ns
1	3	2.0	0.352 ns
2	2.5	1.5	0.429 ns
3	2	0.75	1.811*
4	1	0	1.364*
5	1	0	1.205*
6	0	0	-

In the current study, plaster of Paris cast was applied for 4 weeks. This promotes collagen orientation that is parallel to tendon stress and this agrees with (15). The time taken for complete recovery in our study is four months which is less than the time of five months reported by earlier authors (16). Furthermore early mobilization increasing tendon revascularization, increasing speed of the physiologic healing (17).

Table, 2: Shows the adhesions at two months post-treatment in the two groups

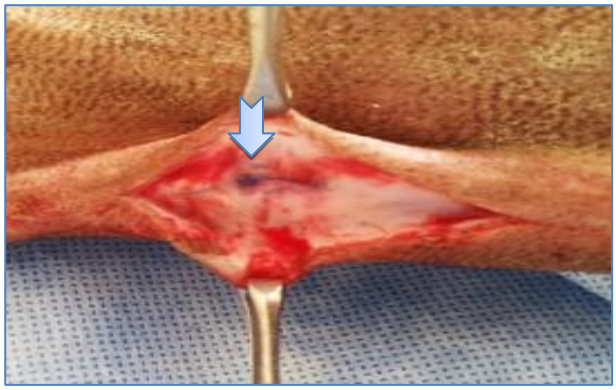
Groups	No. of affected animals	Severity of adhesion (grade 1-3)		
		1 (mild)	2 (moderate)	3 (severe)
First	4	-	1	3
Second	1	-	1	-

In gross examination the pathognomonic findings of the tendons at (two and four months) was the adhesion between the tendon and the overlying skin in both groups. At two months in first group, there were adhesions (100%) (n=3 severe and n=1 moderate adhesions) noticed between Achilles tendon and subcutaneous tissue. In contrast second group, showed the low ratio 25% (n=1 moderate adhesion) (Table, 2 and Fig. 5 and 6). At four months, the ratio of adhesions were

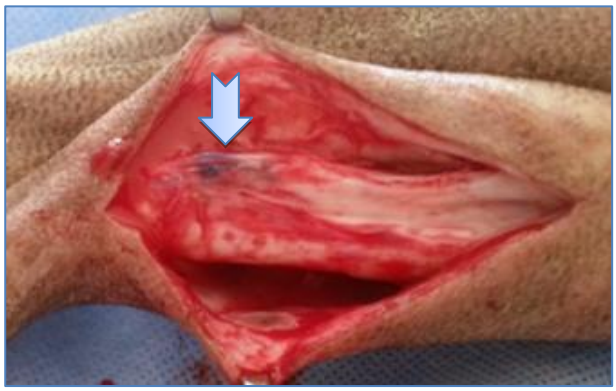
decreased in first group (n=3), in second group (n=1mild case) (Table, 3).

Table, 3: Shows the adhesions at four months post-treatment in the two groups.

Groups	No. of affected animals	Adhesion grade.		
		1 (mild)	2 (moderate)	3 (severe)
First	3	1	1	1
Second	1	1	-	-



Figure, 5: Shows the adhesion in first group, 2 months post-suturing.

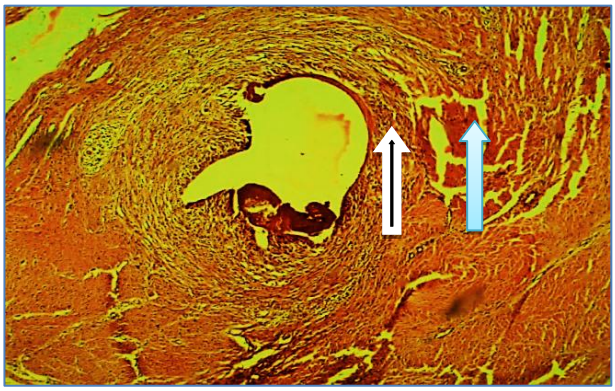


Figure, 6: Shows the adhesion in second group, 2 months post-implantation.

In our study and at two months post-treatment, adhesions were noticed macroscopically. This may be ascribed to several factors which include trauma to the tendon and sheath from the initial injury, which resulted in inflammation and ischemia, in addition to tendon immobilization. A study by (18) referred that one of the major causes of adhesion is a tendon sheath defect after traumatic or surgical injury. Adhesion formation is also increased after an injury, ischemia, immobilization and gapping at the repair site. Such complications compromise tissue properties, interfering with motion, gliding and consequently functionality. Tendon injuries still remain an orthopedic challenge. The time-consuming healing process extends over many months and usually leads to a reparative scar tissue. Scars provide inferior biomechanical stability. Also the poor blood supply and hypo-cellular property of the tendons are thought to be major reasons for their limited self-healing properties (19). The microscopical findings in first and second groups are illustrated in (Table, 4) and (Fig. 7-10).

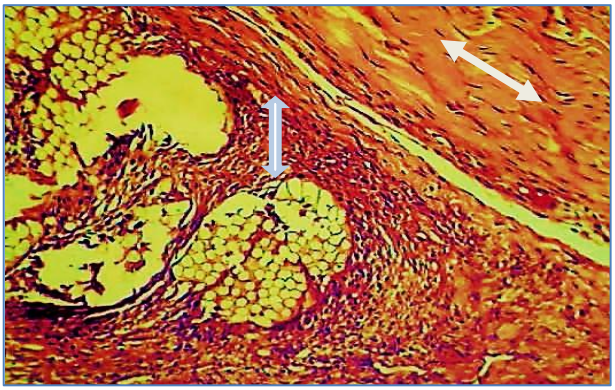
Table, 4: Microscopical findings in first and second groups.

Groups	Time (months)	
	Two	Four
First	There was proliferation of F.C.T around suture materials infiltrated by inflammatory cells, in addition to necrotic tissue attachment to the tendon (Fig. 7).	At this time there were few blood vessels, thickened collagen fibers with MNCs infiltration in cut tendon fibers (Fig.9).
Second	Section in tendon reflected granulation tissue surrounded the narrow mesh holes with tendon fibers expressed proliferation of tenocytes (Fig.8).	There was normal structure of tendon with few MNCs in the epitenon (Fig. 10).

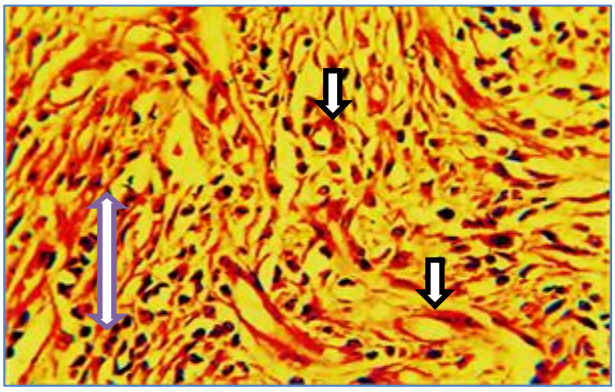


Figure, 7: Histopathological section in tendon of first group, 2 months post-suturing shows fibrous connective tissue proliferation around suture materials infiltrated by inflammatory cells (black arrow) in addition to necrotic tissue attachment to the tendon (blue arrow) (H&E stain; 10X).

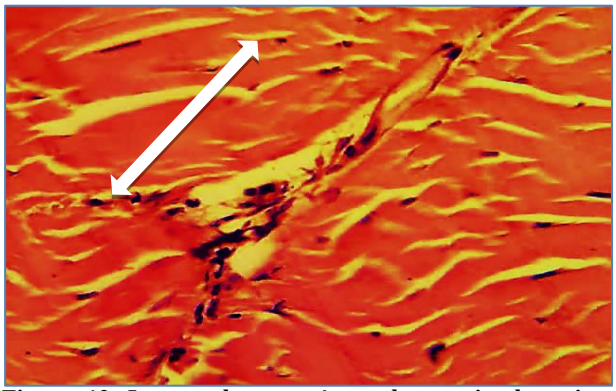
In first group, the evidence of necrotic area representing suture space were seen, this may be related as described by (20) to the process of suturing tendon that causes cells death directly which revealed the formation of an acellular zone that forms around suture within 72 hours and persists for at least one year. This acellular zone forms as a result of tension placed across suture grasp.



Figure, 8: In second group, 2 months post-implantation shows granulation tissue surrounding the narrow mesh holes (blue arrow) with tendon fibers expressed proliferation of tenocytes (empty arrow) (H&E stain;10X).



Figure, 9: In first group, 4 months post-suturing shows few blood vessels (short arrows) thickened collagen fibers with mononuclear cells infiltration in cut tendon fibers (long arrow) (H &E stain; 10X).



Figure, 10: In second group, 4 months post-implantation shows normal structure of tendon with few MNCs in epitenon (arrow) (H &E stain; 40X).

In present study the histopathological data revealed that wrapping the tenorrhaphy site with synthetic mesh accelerates the early repair response of Achilles tendon. The meshes facilitates the approximation of the ends of the tendon few days after injury, inflammation in tendon subsides and fibroblasts proliferation and biosynthesis of extracellular matrix and collagen fibers. In second group the tendon fibers were more organized as compared to the first group. The same was mentioned by (21) who indicated that the fragmentation of the implant caused transfer of the tensile loads and cause areas of stress that stimulate collagen synthesis thereby creating mature longitudinally oriented new tendon fibers filling the gap.

The results of our study revealed increasing in blood vessels this may occur according to hypothesis that the injured tendon suffers decreased blood nutrition and hypoxia that activated macrophages to release angiogenic factors represented by vascular endothelial growth factor (VEGF) which initiate the angiogenesis in the injured site. Also the endothelial cells aggregate in the granulation tissue which lead to proliferation and regeneration of blood vessels. This result agreed with (22).

In current study, the sections of tendon showed proliferation of tenocytes this indicated that both intrinsic and extrinsic mechanisms are believed to contribute to the tendon healing process, this come in line with (23) who indicated that tenocytes within the tendon and epitenon play an important role in the intrinsic mechanism, while in the extrinsic mechanism, inflammatory cells and fibroblasts from the overlying sheath and periphery are the main participants. In the present study the application of polypropylene meshes in bucks revealed no signs of infection that proved its biocompatibility due to the inert nature of the material and its resistance to bacterial contamination, similar interpretation was mentioned by (24). In conclusion, the use of synthetic non-absorbable meshes in the current study had successes in acceleration of collagen deposition and act as scaffold that bridged the cut ends of the tendon thus it increase their tensile strength and stability with superiority of polypropylene mesh in second group when compared with Kessler suture technique in first group.

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دراسة مقارنة لخياطة كسلر وزراعة شبكة البولي بروبلين لإصلاح قطع وتر اكيلس في ذكورالماعز

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الخلاصة

هدف البحث الحالي معرفة كفاءة خياطة كسلر وزراعة شبكة البولي بروبلين لإصلاح القطع المستحدث في وتر اكيلس في ذكور الماعز. اختير للدراسة ستة عشر من ذكور الماعز البالغة وبوزن 35±30 كغم. قسمت الحيوانات بالتساوي إلى مجموعتين. عُدت المجموعة الأولى كمجموعة سيطرة (خياطة كسلر) أما المجموعة الثانية (مجموعة الشبكة) فقد استعمل لها شبكة بولي بروبلين. استعمل الزايلازين 2% والتخدير الموضعي بمادة الليدوكائين هيدروكلورايد 2%. فتح الجلد بطول خمسة سنتميترات. اجري التشريح الأعمي لفصل الوترعن الأنسجة المجاورة ثم أدخل ملقط قاطع النزف أسفل الوتر واستخدم المشرط الجراحي لقطعه في المنتصف. أصلح الوتر في مجموعة السيطرة باستعمال خياطة كسلر وبخيط بولي بروبلين قياس (1). زرعت شبكة البولي البروبلين بالمجموعة الثانية حيث تم لفها على الوتر وتثبيتها بغرز من نوع البسيط المتقطع. أغلق الجلد والأنسجة تحته بطريقة المنجد المتوازي وبخيط الحرير قياس (1) ثم استعملت جبيرة باريس لتثبيت منطقة العملية وعملت فتحة بالجبيرة. ازيلت الخيوط الجراحية على الجلد بعد مضي 10يوم. أظهرت النتائج السريرية حصول العرج في جميع الحيوانات حيث لم يلاحظ اي فرق إحصائي معنوي بين المجموعتين في الأسابيع الثلاثة الأولى. بدأ العرج بالاختفاء تدريجياً بدءاً من الأسبوع الرابع بعد العملية حيث لوحظ فرق إحصائي معنوي $P<0.05$ بين المجموعتين واختفى العرج في الأسبوع الرابع في المجموعة الثانية والأسبوع السادس في المجموعة الاولى. اجري الفحص العياني والنسجي- المرضي في الحقبة الممتدة بين الشهر الثاني والرابع بعد إصلاح الوتر حيث لوحظ في الشهر الثاني وجود التصاقات بين الوتر والأنسجة تحت الجلد وكان نسبتها 100% في المجموعة الاولى ونسبة (25 %) في المجموعة الثانية. أوضح الفحص النسجي المرضي بعد شهرين من الخياطة وجود النسيج الليفي مع ارتشاح الخلايا الالتهابية. في مجموعة الشبكة وفي المدة نفسها لوحظ وجود النسيج الحبيبي الذي أحاط بثقوب الشبكة مع ألياف الغراوين وخلايا الوتر. في الشهر الرابع، اظهرت المجموعة الأولى وجود أوعية دموية قليلة، تتخن ألياف الغراوين مع ارتشاح خلايا وحيدة النواة في منطقة قطع ألياف الوتر. في المجموعة الثانية،عاود الوتر تركيبه الطبيعي مع ارتشاح خلايا وحيدة النواة. نستنتج بأن كلتا التقنيتين تمكنت من إصلاح الوتر مع تفوق واضح للمجموعة الثانية عند مقارنتها مع المجموعة الاولى.

الكلمات المفتاحية: خياطة كسلر، شبكة البولي بروبلين، زراعة، وتر اكيلس، ذكور الماعز.