EFFECT OF SHORT-WAVE DIATHERMY ON ACHILLES TENDON HEALING IN RATS.

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INTRODUCTION

Despite advances in surgical technique, management of ruptured tendon still presents a challenge and continues to be among the most difficult rehabilitation management problem (Enwemeka, 1989 a). Unlike most soft tissues, tendons require several weeks of healing in plaster cast immobilization after surgical repair (Nistor, 1981). In cases of Achilles tendon ruptures, the period of immobilization may last as long as 12 weeks, producing muscle atrophy , articular cartilage atrophy, skin necrosis and tendocutaneous adhesions (Carden et al., 1987). If healing can be quickened, then the duration of cast immobilization may be reduced to minimize these complications (Langlais et al., 1989). Several investigators used physical agents and procedures to quicken tendon healing, but 8 or more weeks of plaster immobilization are still required (Roberts et al., 1982 and Akai et al., 1988).

Short-wave diathermy is the commonest form of electromagnetic waves used (Barker et al., 1983). When the diathermic current is passed through the tissues there is increased temperature through the oscillation of polar molecules (Lehmann,1980). Associated with the increase in tissue temperature is an increase in blood flow (Abramson, 1960). Elevated tissue temperature and enhanced blood flow may enhance recovery from injury, as well as relief of pain and spasm (Lehmann et al., 1974). The results of several human clinical and animal laboratory studies revealed improved connective tissue healing, increase collagen extensibility and faster resolution of edema, exudate and hematoma (Goldin et al., 1981). Fibroblastic activity, collagen deposition and new capillary growth appeared more rapidly in skin tissues from animals treated with short-wave than in those from untreated animals (Barclay et al., 1983). Less favorable results were obtained in cases of sprained ankles (Barker et al., 1985). Barker et al., asked why this modality is used at all as they proved that short-wave diathermy has no effect on the treatment of ankle sprains.

This study was an attempt to address the need for more knowledge and a better understanding of short-wave diathermy and its effect on the healing of tenotomized and repaired tendoachilles.

MATERIAL AND METHODS

Eighty Albino rats of both sexes, each weighing between 190 and 260 g, were used in the experiments. After the rats were anesthetized under ether, longitudinal skin incisions were made over the right tendoachilles . By blunt dissection, the tendon was separated from the adjoing tissue and severed sharply and transversely midway between its musculotendinous and osseotendinous junction. The severed ends of the tendon were then approximated and sutured with 2-0 black surgical silk. Subsequently, the skin incision was closed by three stitches of 2 - O black slik and bathed with iodine solution. Following recovery from anesthesia, animals ambulated freely on their four limbs. The animals were then mixed and divided randomely into two equal groups : experimental and control groups. The rats of each group were kept in separate cages and in the same standard conditions. The only difference in procedure being the application of short-wave diathermy . The rats in the experimental group underwent short-wave diathermy every other day for 15 minutes every session, while rats in the control group were mock treated. Automatic short-wave diathermy (Rechotherm - Prina - German) was used. A double layer of sheeting was placed over the treated limb. Two small condenser plate applicators were placed on both sides of the treated leg. The short-wave diathermy was positioned so that the injured tendoachilles was in the center of unit's magnetic feild and a space of 0.5 inch was maintained between the applicator head and the treated muscle. At all times in this study, power was held constant at the second degree to avoid overheating of the treated part.

A test lamp was used between the 2 electrodes during each sitting to ensure proper tretment. Assessment of proper and mock short-wave treatment were done after 10 and 20 days . After 10 days of treatment half of the rats in each group (n = 20) were reanesthetized and the skin incisions reopened and the tendons freed very carfully from the surrounding tissue after which the tendon sutures were removed. During dissection, the degree of peritendinous adhesions was evaluated as mild or marked adhesions (Seyfer and Bolger, 1989).

After tendon freeing, 10 tendons were subjected to tendon breaking strength evaluation (Owoeye et al., 1987) while the other 10 tendons were evalua ted histologically.

The tendon breaking strength was done by immediate stress test in grams required to rebreak the surgical site. A preliminary study proved that rat tendons can heal after 20 days but the strength of this site was still far below that of the rest of the tendon , so that rerupture always occurred through it. After freeing the tendons in 10 rats, the tendons were removed by incising some bone at the site of the insertion at the calcaneus to prevent silk slippage. 2 - O silk was tied securely at the osseotendinous junction, while the other end was attached to pull strain gauge equipped with a reading pointer (SEA- German). With the rat fixed on the table, the gauge was pulled very gradually, in a horizontal direction, until the repaired site of the tendon ruptured and a recording was taken at this point. The animals were then sacrificed with an overdose of ether.

After tendon freeing, the other 10 tendons were subjected to histological examination. One centimeter of the tendon centered at the repair site was fixed in formalin for histologic preparation with hematoxylin and eosin. The animal was then sacrificed with an overdose of anesthesia. The grade of healing was determined according to the degree of formed collagen fiber. Stage 1 = non union , stage 2 = mild collagen fiber deposition, stage 3 = moderate collagen fiber deposition, stage 4 = well formed and columnarly riented collagen fibers (Enwemeka 1989 b).

This process of evaluation was repeated after 20 days of treatment in the remaining rats (n = 20 in both the experimental and control group). The results of the experimental and control groups at each period of treatment were statistically evaluated using x^2 and student's t-test.

RESULTS

I- After 10 days of treatment :

* At dissection , one tendon was found to be ruptured in the experimental group, while they were two in the control group.

* During dissection , peritendinous adhesions was demonstrated in 9 rats in the experimental group(one marked and 8 mild), while in the control group , it was demonstrated in 10 rats (one marked and 9 mild), ($P > 0.05$).

* Both the tendon breaking strength and grade of healing of the experimental group were insignificantly higher than those of the control group (Table 1 & 2 and Fig. 1 & 2).

II- After 20 days of treatment :

* At dissection, no tendon was found to be ruptured in the experimental group, while they were two in the control group.

* During dissection , peritendinous adhesions was demonstrated in 10 rats in the experimental group (one marked and 9 mild), while in the control group , it was demonstrated in 18 rats (4 marked and 14 mild), ($P < 0.001$).

* Both the tendon breaking strength and grade of healing of the experimental group were significantly higher than those of the control group ($P < 0.01$ & 0.005 respectively), (Table 1 & 2 and Fig. 3 & 4).

DISCUSSION

Management of tendoachilles rupture is particularly challenging for the clinician because of the lengthy period of immobilization entailed in its repair, whether it is done surgically or non surgically (Frieder et al., 1988). The period of immobilization ranges from 8-12 weeks, depending upon the procedure, during which muscle strength and range of motion of the involved limb are severely compromised (Woo et al., 1981 and Amadio et al., 1988). In addition, restoration of the prior level of function, especially for the profesional athlete cannot be assured due to presence of peritendinous adhesions (Kulick et al., 1986 and Chow et al., 1988).

This study indicates that short-wave diathermy , as used, does not significantly promote tendon recovery after 10 days of treatment (Fig. 1, 2). If treatment was prolonged to 20 days, faster healing of the injured tendon occurred (Fig. 3 & 4). The tendon breaking strength seemed to be greater and grade of tendon healing appeared to be at a more advanced stage in the experimental group when compared to the control group. Also, short-wave diathermy decreased the amount of peritendinous adhesions in comparison to the control group. This management approach potentially reduces the amount of time necessary for the entire rehabilition process of tendon rupture. The beneficial effect of short-wave diathermy may be attributed to the facilitation of fibroblast proliferation and collagen synthesis, two processes which are known to occur in tendon healing (Cameron, 1961). The mechanism of action was not clearly understood. There is disagreement about whether the effects are specific or simply due to the mild heating. Some e.g. Lehmann and DeLateur (1982) maintain that all the proven effects can be accounted for by mild heating . Other , pointing to other effect suggesting that electrical changes may influence cellular membrane function (Barclay et al., 1983). Cell damage is associated with depolarisation and it is suggested that recovery may be assisted by ionic movement provoked by the varying electric field (Hayne, 1984). Cell division and other cellular activities may be aided by the vibrating charges of short-wave (Hayne, 1984). The heating causes an increased blood flow and tissue metabolism which assists resolution (Low, 1988). Both degeneration and repair proceed simultaneously, so that quite a small change may tip the balance in favour of resolution.

Peritendinous adhesions which develop after injury or operation are still a major problem (Kulick et al.,1986). The adhesions that are part of the healing process constitute an almost inevitable functional disability during the biological response of the tissue to injury (Manske, 1985). Adhesions will form between the tendon and surrounding tissue at a point where the tendon surface is broken, due to the presence of inflammatory exudate (Kulick et al., 1984 and Vander Salm et al 1986). To achieve better gliding function of tendons, continuous efforts are being made to reduce peritendinous adhesions without adversely affecting the healing process itself. This was obtained from the short-wave diathermy after 20 days of treatment, as proved throughout this experimentation. The adhesion - reducing effect of the short-wave observed in the present study may be due to washing out of the post-traumatic edema, inflammatory cells and exudate by enhancement of the venous and lymphatic circulation (Low, 1988). These physiological changes are produced by a direct effect of the temperature elevation and by a reflex mechanism (Sekins et al., 1982). This also may be due to restoration of the membrane potentials of damaged cells (Hayne, 1984).

The observed beneficial effects of short-wave diathermy in this study was supported by many other studies. Experimentally induced skin wounds showed less edema when treated (Cameron, 1961). Artificialy produced hematomas in rabbit ears have been shown to heal faster undertreatment (Fenn, 1969). In a study on children after orchidopexy less bruising and more rapid recovery was found in those treated with short-wave diathermy (Bentall and Eckstein, 1975). Experiments on the median - ulnar nerve of rats indicated that those treated for 15 minutes /day showed quicker and more complete regeneration than the controls (Wilson and Jagadeesh, 1976 and Wilson, 1981). A double blind study on the donor site healing after split skin graft removal showed significantly greater healing at 7 days in those treated compared with the controls (Goldin et al., 1981). Carefully designed experiments involving the division and suture of the common peroneal nerve of rats demonstrated statistically significant benefits with short-wave treatment with acceleration of regeneration and maturation of myelinated nerve fibers while fibrosis was reduced (Raji, 1984).

The rats were selected as experimental animals because they were available easily and in abundant number, they were easy to care, and that death risk at anesthesia was very low. Ether anesthesia was applied on the animals in our experiments during operations with no death being encountered. Also the rat Achilles tendon could be easily incised and repaired.

In conclusion, short-wave diathermy for 20 days, could be a tremendous adjunct in the surgical management of tendon rupture as it proved to enhance tendon healing and decrease peritendinous adhesions. This can decrease the complications of tendon healing and decrease the time required for rehabilitation after tendon repar.

short-wave (experimental) group when compared to the mock - treated (control) group.

SUMMARY

This study was to evaluate the effect of short-wave diathermy on the healing of tenomized and repaired rat's tendoachilles.The right tendoachilles of 80 rats were tenomized and sutured with 2-0 silk. Rats were divided equally into an experimental and control groups. On the next day, the right tendoachilles of the experimental group were treated with short-wave diathermy while the right tendoachilles of the control group were mock - treated. Sittings were given every other day for 15 minutes. Half of the rats from each group (n = 20) were evaluated after 10 days of treatment, while the other half were evaluated after 20 days of treatment. After 10 days of treatment, no significant differences were demonstrated between the experimental and control group regarding peritendinous adhesions, tondon breaking strength or histological grade of healing. If treatment continuoud for 20 days, highly significant reduction of peritendinous adhesion and highly significant increase in the grades of tendon healing, were observed in the short-wave (experimental) group when compared to the mock - treated (control) group.

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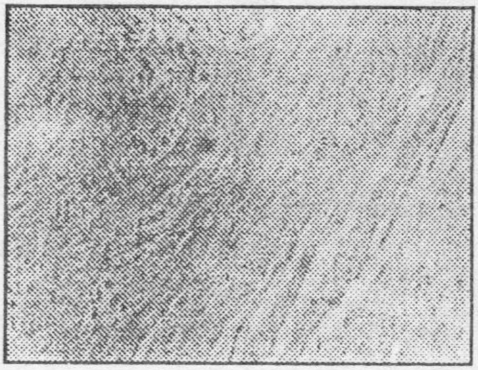

Fig. 1 : Longitudinal section of Achilles tendon at the healing site, 10 days after mock treatment, showing numerous fibroblasts and lightly aggregated collagen fibrils (grade 1, Hx.& E. X 100).

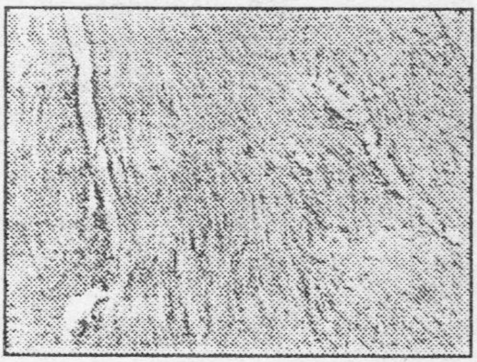

Fig. 2 : Longitudinal section of Achilles tendon at the healing site , 10 days after short-wave therapy, showing mature and fewer fibroblasts and moderate amount of collagen fibrils (grade 2 , Hx. & E. X 100).

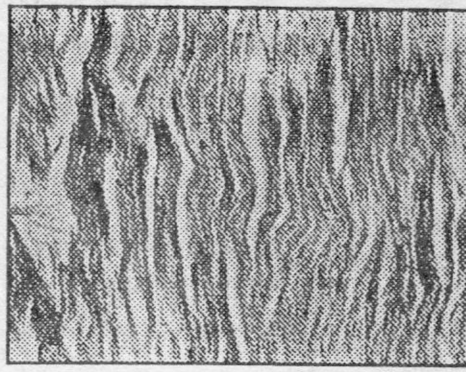

Fig. 3 : Longitudinal section of Achilles tendon at the healing site, 20 days after mock - treatment, showing the periodicity of moderate oriented collagen fibrils which are not densely packed (grade 3, Hx. & E. X 100).

Fig. 4 : Longitudinal section of Achilles tendon at the healing site, 20 days after short-wave therapy, showing the more densely aggregated collagen fibrils and the more uniform orientation (grade 4, Hx. & E. X 100).

Table 1 : The degree of improvement between the breaking strengths of the experimental and control groups (by kilogram).

GROUP	AFTER 10 DAYS		AFTER 20 DAYS	
	n	Mean ± S. D.	n	Mean ± S. D.
Experimental.	10	1.116 ± 0.136	10	3.146 ± 1.803
Control.	9	0.975 ± 0.194	9	1.430 ± 0.157
P		> 0.05		< 0.01

n = Number of rats

P = Statistical level of significance between the experimental and control groups after the same periods of assessment.

Table 2 : The degree of improvement between the histological grade of tendon healing of the control and experimental groups :

GROUP	AFTER 10 DAYS		AFTER 20 DAYS	
	n	Mean ± S. D.	n	Mean ± S. D.
Experimental.	9	1.816 ± 0.581	10	3.426 ± 0.651
Control.	9	1.301 ± 0.0492	9	2.316 ± 0.778
P		> 0.05		< 0.05

n = Number of rats

P = Statistical level of significance between the experimental and control groups after the same periods of assessment.

الملخص العربى

تأثير الأستحرار بالموجات القصيرة على ألتئام وتراكيليس فى الفئران

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أستهدفت هذه الدراسة معرفة تأثير الأستمرار بالموجات القصيرة على درجة ألتئام قطع وتراكيليس، حيث تم أحداث قطع كامل ثم أصلاحة بوتر اكيليس الأيمن فى عدد ثمانين فأراً قسموا بالتساوى بطريقة عشوائية إلى مجموعتين : اختبارية وضابطة. وبعد يوم واحد من عملية الاصلاح عرضت الأوتار اليمنى للمجموعة الاختبارية للأستمرار بالموجات القصيرة يوم بعد يوم لمدة خمس عشرة دقيقة، بينما عرضت الأوتار اليمنى للمجموعة الضابطة لأجهزة موجات قصيرة غير عاملة، وتم تقييم التأثير العلاجى للموجات القصيرة بعد عشرة ثم بعد عشرين يوماً من بداية العلاج، وذلك بتقدير درجة الألتصاق حول الأوتار، القوة اللازمة لقطع ألتئام وتراكيليس والفحص الهستوباثولوچى لمكان الألتئام، وذلك بعد أزالة الحرير الموجود بمكان القطع.

أوضحت نتائج هذا البحث أن العلاج بالموجات القصيرة لمدة عشرة أيام لايعطى درجة ألتئام ذات دلالة أحصائية من حيث تقليل الألتصاق حول الوتر، وتحسن القوة اللازمة لقطع الوتر أو لدرجة الألتئام الهستوباثولوچية، بينما إذا استمر العلاج بالموجات القصيرة لمدة عشرين يوماً فإنه يظهر تحسن ذو دلالة أحصائية فى هذه الدلالات فى المجموعة الأختبارية إذا قورنت بالمجموعة الضابطة.