

## **A Comparative Study: The Effect of Pulsed and Static Magnetic Field on The Healing of Rupture of Achilles Tendon in Rabbits**

ISSN -1817 -2695

**I. MH. Alrashid**

*Department of Medicine and Surgery, College of Veterinary Medicine,  
University of Basrah /Iraq*

Email: [dr\\_ibrahimveterinary@yahoo.ca](mailto:dr_ibrahimveterinary@yahoo.ca), mob: +9647703169873

((Received 4/4/2011, Accepted 12/6/2011))

### **Summary**

The pulsed and static magnetic field were used in treatment of tenectomy achilles tendon, which no significant results at level of  $P \geq 0.05$  in both groups. Eighteen rabbits were used in present study, the animals were divided into three equal groups, 1<sup>st</sup> group was treated with pulsed magnetic field (650 Gauss, 50 Hz), 2<sup>nd</sup> group was treated with static magnetic field (650 Gauss), while 3<sup>rd</sup> group was used as a control group. The magnetic therapy was continued to four weeks post surgery/ twice daily. Clinical signs were recorded to all groups, loading force and jumbling power tests which used in athletics to knowledge achilles tendon sufficiency post surgery. The magnetic treated groups were showed significant result with control group at  $P \geq 0.05$ , while no significant results at  $P \geq 0.05$  between pulsed and static groups. Blood parameters were examined, there significant result at between magnetic groups and control group at  $P \geq 0.05$  during the 1<sup>st</sup>-four weeks (treatment period), while return to insignificant at seven weeks post surgery at  $P \geq 0.05$ . The gross and histopathological picture were taken at seven post surgery, semi complete healing in magnetic groups, while control group was showed more collagen and fibroblast. *In conclusions of this study*, the magnetic field therapy have ability to acceleration healing the rupture tendon increase blood parameters. Theoretically, the mechanism of action magnetic field to accelerate healing was discussed.

**Key words** : pulsed magnetic field, static magnetic field, achilles tendon, tendon, tendon healing.

**Author address** : Iraq/ Basra – University of Basra/ College of Veterinary Medicine / Department of Medicine and Surgery.

### **Introduction**

The achilles tendon constitutes the distal insertion of gastrocnemius unit(1,2 and 3) . Gastrocnemius muscle has its originated below knee joint at the posterior aspect of proximal tibia and fibula, the distal end of Achilles tendon insert with calcaneal bone (2). The majority of the cells in the tendon are fibroblasts and collagen fibers, it seems like cells form three dimensional network, it can form the basis of loading-sensing system that allows a tendon to modulate the composition of extra-cellular matrix in response to change in the loading pattern (4). Neighboring arteries provide muscular branches that usually supply tendon sheath and tendon sheath which is supply tendon

fibers by capillaries bed longitudinally, blood flow in achilles is surprisingly high approximately 0.10 mL/g/min, which increase in exercise (2and7). Achilles tendon is innervated by the attaching muscles, particularly in the Sural nerve (8) Achilles tendon highly effecting with physical factors such as sever loading, sever tension in sportsman, horserace as well as torsion, also effecting by pathological factors such as tendonitis, tendinopathy and tumor, which are finally cause tendon rupture (9). The optimal post operative rehabilitation protocol after surgery repair of an achilles tendon rupture is involving from the classical routine using rigid immobilization in below-knee bone to

calcaneal bone (10). the first possible biological response of healing of tendon rupture dependent effect on fibroblast metabolism and collagen deposition (11), the mechanism regulation of collage deposition effect by transforming growth factors (TGF) including transforming growth factor- $\beta$  (TGF- $\beta$ ), connective tissue growth factor (CTGF), insulin like growth factor (ILGF), and platelet-derived growth factor (PDGF) as well as inflammatory cells such as macrophages, cytokines, interleukins (12).

There are three ways to treat the effect of achilles tendon: biological applicant treatment such as sheep umbilical cord, sheep intestinal mucosa, and dog bone marrow(13); chemical

applicant treatment such as non steroidal anti inflammatory drugs (NSAIDs) and hyaluronic acid (14); and physical applicant treatment such as laser therapy, ultrasonic therapy, thermotherapy, electrical shock wave therapy, magnetic field therapy (15).

Magnetic field therapy in achilles tendon uncommon in human and animals, in spite of have good application and results, there few reports were documented the magneto therapy in achilles tendon rupture repair as well as don't explain the mechanism of action of magnetic field on healing of achilles tendon (3). the aim of this study was to compare between two treatments of tenectomy of achilles tendon.

### Materials and Methods

In present study eighteen rabbits were used (*Lepus cuniculus*) same genera (male), age  $8 \pm 2$  months, live in similar condition and fed with bread and hay, which were divided into three groups, 1<sup>st</sup> and 2<sup>nd</sup> groups were treated groups while the 3<sup>rd</sup> group was control. 1<sup>st</sup> group was treated by pulsed magnetic field with (650 G,

50Hz), 2<sup>nd</sup> group was treated by static magnetic field with (650 G),

-Magnetic field apparatus, which include 1- (power supply enriched with ammeter and voltmeter), 2-magnetic coil, 3-animals beds, and 4-compass.



**Figure (1) Magnetic field apparatus**

-Anesthetic agent (xylazine +ketamine), antibiotic drugs ( penicillin- streptomycin ).

The surgical operation was achieved under general anesthesia ( 3mg xylazine +10mg ketamine) (16), in the dorsal view (fig.2).

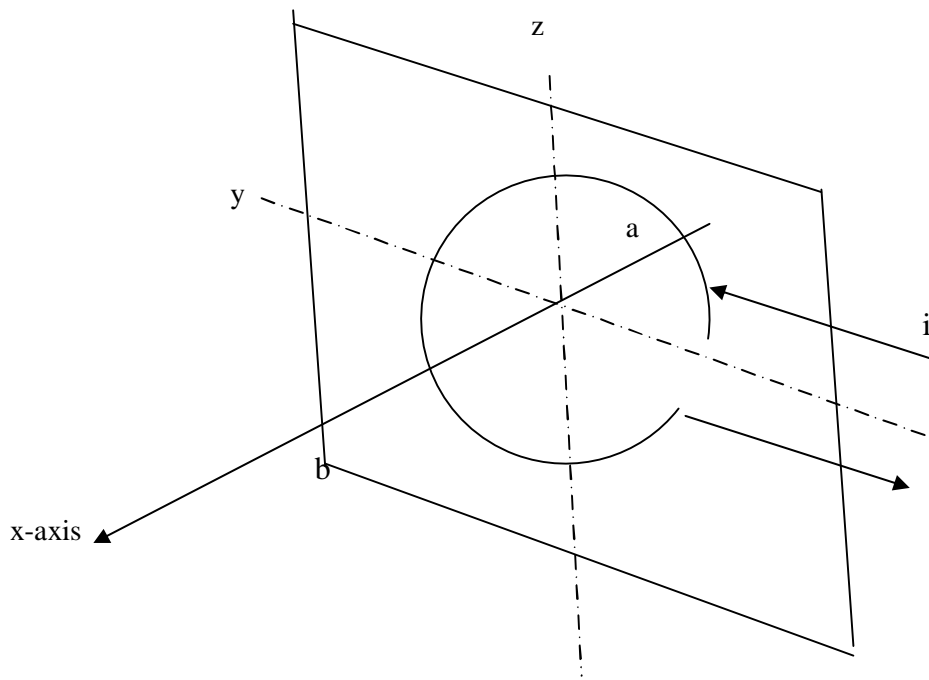


**Figure, 2 Show exposure of achilles tendon**

Carefully ,under aseptic technique the achilles tendon was appeared and incised( complete cutting) near the distal end and sutured with absorbable suture by two arrows, 1<sup>st</sup> arrow simple interrupted pattern, 2<sup>nd</sup> arrow by special suturing (looking loop pattern) (17). Looking loop pattern means the rupture tendon suture by double pair loop ties together tightly .Skin was

suture by blanket suture with silk suture and removed after 7 day post operation, the animals weights were measured before operation and repeated weekly post operation.

The 1<sup>st</sup> and 2<sup>nd</sup> groups were exposed to pulsed and static magnetic field after surgery by range (15 min /12 hr / twice daily) ( fig 3)



**Figure 3: site of magnetic application on achilles tendon rupture**



This diagram illustrate the mechanism of current to produce magnetic field and measurement the

magnetic dose (X is toward the magnetic field )

$$\beta = \frac{\mu_o}{2} \cdot \frac{ina^2}{(a^2 + b^2)^{3/2}}$$

i: is the current through the turn

n: number of turn of coil

a: is the radius of the turn

b: is the axial distance from and perpendicular to the turn plane. When  $\mu_o$  is the permeability of free space ( $\mu_o = 12.57 \times 10^{-7}$  Weber/ amp. m)(16, 18 and 19).

Exercises test also were measured that include Load test and Jumped test. Load test is a sport test to measured the ability the human or races to carry himself per time depending upon its ankle joint and Achilles tendon (20).

$$L = w * a / t$$

L= Load (power), w= weight of body, a= specific gravity, t= the period which animal stay

stand up when it eat its food vertically . Jumped test is a sport test to measure the ability of human or races to reach to highest point with special column (22).  $J = w * a / h$

J= jumped power, w=body weight, a= specific gravity, h= highest point when animal jumped to eat its food which put in it.

Cross picture and histopathology picture were taken at 7 week after surgery. Blood profile was recorded at 1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, 4<sup>th</sup>, 5<sup>th</sup>, 6<sup>th</sup>, and 7<sup>th</sup> weeks. Theory study to knowledge the mechanism of magnetic field therapy behaves to healing of cutting achilles tendon.

## Results and Discussion

The experimental animals in all groups were showed stagger at gait during 3 days post operation , but this sign was disappeared after 4 days post surgery in 1<sup>st</sup> and 2<sup>nd</sup> groups, while it persisted until 6-7 days post operative surgery in control group. The effect of pulsed and static magnetic field to assist the

wound healing by direct and indirect effect on wound healing and pain relief, which accelerate wound healing and provide pain relief, this agree with *Alrashid et al* (19). The results of the loading test and jumping test were summarized in table(1 a, b, c)

Table (1.a) pulsed magnetic group

Period	Weight $\pm$ SD	Loading Time/min $\pm$ SD	Loading Force(N/min)*	Jumping High /M $\pm$ SD	Jumping Power(N/M)†
1 week	1.73 $\pm$ 10	11.8 $\pm$ 2.5	1.436	-	-
2 week	1.8 $\pm$ 0.5	11.2 $\pm$ 0.6	1.575	-	-
3 week	1.75 $\pm$ 0.8	13.7 $\pm$ 1.3	1.250	-	-
4 week	1.7 $\pm$ 14	14.2 $\pm$ 0.9	1.173	60 $\pm$ 20	27.766
5 week	1.8 $\pm$ 16	16.36 $\pm$ 2.8	1.083	79 $\pm$ 0.3	22.329
6 week	1.86 $\pm$ 13	21.29 $\pm$ 1.3	0.773	84 $\pm$ 85	21.700
7 week	1.88 $\pm$ 13	23.57 $\pm$ 1.4	0.781	99 $\pm$ 18	18.610

SD: standard deviation

\* : P $\geq$  0.05 significant value among 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> groups

† : P $\geq$  0.05 significant value among 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> groups

Table(1.b) static magnetic group

Period	Weight $\pm$ SD	Loading Time/min $\pm$ SD	Loading Force(N/min)*	Jumping High /M $\pm$ SD	Jumping Power(N/M)†
1 week	1.63 $\pm$ 0.5	12 $\pm$ 2.9	1.331	-	-
2 week	1.60 $\pm$ 15	13.1 $\pm$ 0.3	1.169	-	-
3 week	1.70 $\pm$ 0.9	15.6 $\pm$ 1.6	1.067	-	-
4 week	1.8 $\pm$ 14	17.6 $\pm$ 0.3	1.002	62 $\pm$ 31	28.451
5 week	1.8 $\pm$ 14	18.8 $\pm$ 0.8	0.953	88 $\pm$ 0.7	20.713
6 week	1.86 $\pm$ 15	23.3 $\pm$ 1.2	0.782	97 $\pm$ 71	18.791
7 week	1.9 $\pm$ 16	25.9 $\pm$ 2.6	0.718	111.16 $\pm$ 20	16.774

SD: standard deviation

\* : P≥ 0.05 significant value among 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> groups

† : P≥ 0.05 significant value among 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> groups

**Table (1.c) control group**

Period	Weight ±SD	Loading Time/min±SD	Loading Force(N/min) *	Jumping High M±SD	Jumping Power(N/M)†
1 week	1.5±0.5	7.3±1.6	2.013	-	-
2 week	1.5±0.8	7.32±1.6	2.008	-	-
3 week	1.6±0.6	6.21±2.1	2.524	-	-
4 week	1.6±60	7.53±1.1	2.147	24±0.3	65.333
5 week	1.48±14	7.32±1.6	1.981	27±14	53.718
6 week	1.51±14	9.03±1.1.6	1.638	28±28	52.500
7 week	1.6±12	9.94±2.3	1.577	29±83	54.0068

SD: standard deviation

\* : P≥ 0.05 significant value among 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> groups

† : P≥ 0.05 significant value among 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> groups

The loading test and jumping in pulsed magnetic group and static magnetic group compare with control group reveals to

development of achilles tendon healing better than control group.

**Blood profile**, were recorded RBCs, WBCs and HB of animal groups, show in table (2) .

**Table(2) blood parameters in different period**

Groups period	Pulsed Magnetic Group*			Static Magnetic Group*			Control†		
	RBC 10 <sup>12</sup> +SD	WBC 10 <sup>9</sup> +SD	HB g/dl+SD	RBC 10 <sup>12</sup> +SD	WBC 10 <sup>9</sup> +SD	HB g/dl+SD	RBC 10 <sup>12</sup> +SD	WBC 10 <sup>9</sup> +SD	HB g/dl+SD
<b>1 week</b>	5.4±1.9	4.8±0.8	10.4±1	5.7±1.9	4.8±0.8	10.4±1	5.5±1.3	6.7±0.8	8.1±1
<b>2 week</b>	5.6±9.2	5.4±5.1	10.5±2	5.9±9.2	5.4±5.1	10.5±2	4.7±5.6	5.2±1.3	7.1±0.9
<b>3 week</b>	7.4±3.5	6.6±1.4	11±0.4	7.1±3.5	6.6±1.4	11±0.4	5.4±1.9	4.3±5.6	8.5±2
<b>4 week</b>	7.5±0.9	5.1±.15	11.7±1	7.9±0.9	5.1±.15	11.7±1	5.6±9.2	6.7±0.8	7.5±1
<b>5 week</b>	6.1±0.8	4.7±0.1	10.1±1	6.7±0.8	4.7±0.1	10.1±1	6.1±0.8	4.8±0.8	7.1±0.9
<b>6 week</b>	5.5±1.3	4.7±1.2	9.1±0.9	5.2±1.3	4.7±1.2	9.1±0.9	5.5±1.3	5.4±5.1	8.2±2
<b>7 week</b>	4.7±5.6	4.3±7.3	10.5±2	4.3±5.6	4.3±7.3	10.5±2	15±5.1.	6.6±14	8.5±2.3

SD: standard deviation

\* : P≥ 0.05 significant value among 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> groups from 1-4 weeks

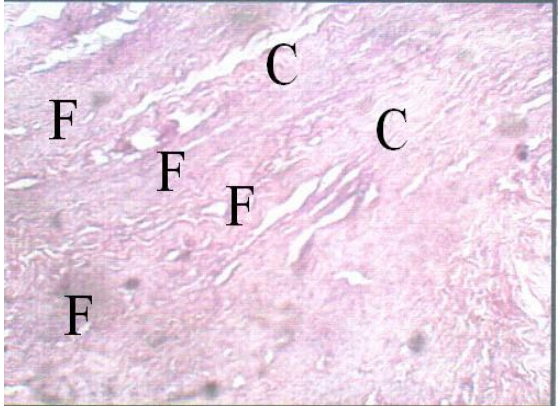
† : P≥ 0.05 no significant value among 1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> groups from 5-7 week

The effect of magnetic field either pulsed or static effects on blood store in body either bone marrow which cause increase blood parameters,

therefore providing blood nutrition and increase blood circulation in tendon sheath area lead to increase tendon healing this finding agree (22).

**Gross pictures and Histopathology pictures,**

**Pulsed magnetic field group post 7 weeks of surgery, figure ( 4 and 5)**

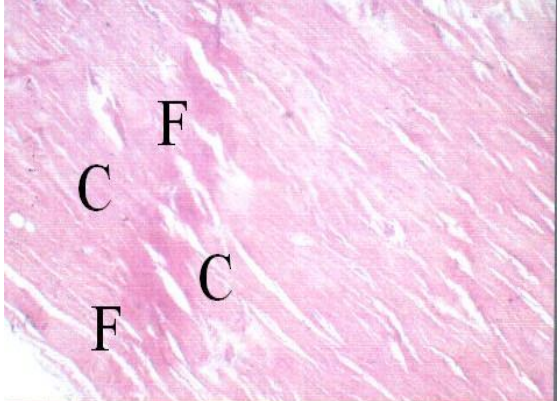


Histopathology of Achilles tendon showed few fibroblast F and collagen depositions C, (E& H stain) 100X



Image of Achilles tendon showed line of healing and swallowing of junction area

**Static magnetic field group post 7 weeks of surgery figure (6 and 7)**



Histopathology of achilles tendon showed few fibroblast F and collagen depositions C (E& H stain) 100X

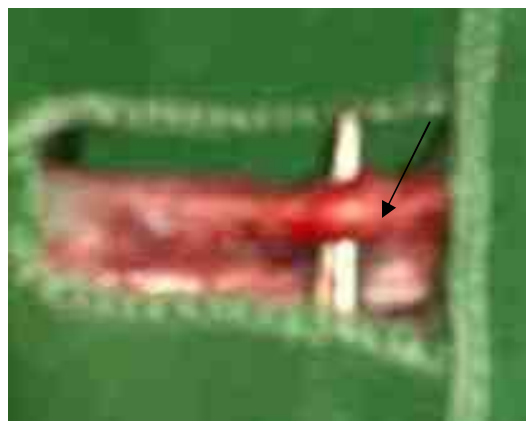
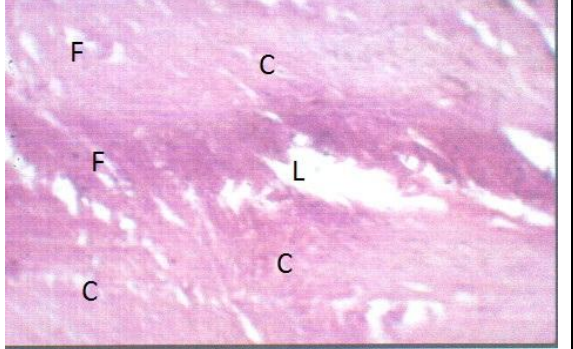


Image of achilles tendon showed line of healing semi normal

**Control group post 7 weeks of surgery figure (8 and 9)**



Histopathology of achilles tendon showed much fibroblast F and collagen depositions C, L line of healing (E& H stain) 100X

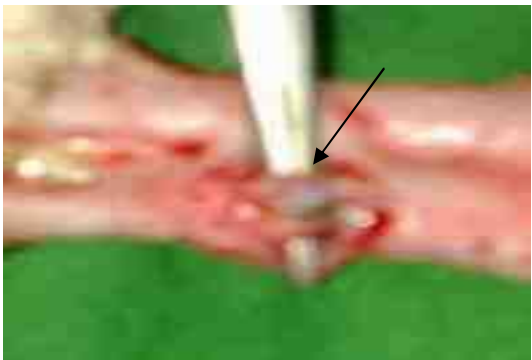


Image of achilles tendon showed line of healing and residue of cut gut suture





The gross and histopathological images don't mainly depend on tendon research because they don't take real image for rupture tendon healing, but the gross and histopathology was used in present study to reveal some biological process of rupture tendon healing , after 7 weeks show complet healing in pulsed and static magnetic groups compare with control group, it show line of healing and more fibrosis in histopathology image and show cut-gut suture residues in gross picture ( fig.4 and 5) , this comparison reveals to the treated groups healing highly develops better than control groups (fig. 8 and 9).

The magnetic field highly uses application in medicine and surgery, these reports don't

mention the dangerous side effect except in high tension of magnetic field(23 and 24). The present study doesn't agree or disagree with other reports except Degner (11), he used pulsed magnetic field to treatment defect tendon in horse with (3600 Gauss, 30 Hz) and he record several disadvantage such as oedema, blood oozing and skin discoloration; while no reports were used moderate dose (300-1000 Gauss). The process of healing by use magnetic field regards to the mechanism of magnetic field action on rupture tendon and whole body , this process was summarized in (fig. 10)

### **Mechanism of magnetic field action on rupture tendon healing( theory)**

There are no reports discusses the role of magnetic field by detailed steps, in present study suggest this mechanism which simulate the mechanisms of magnetic field in fractured bone (*Alrashid et al.*)(19), in experiment the magnetic field either pulsed or static was exposed directly to the dorsal view of achilles tendon and bones( tibia and fibula), in tendon, the magnetic field stimulates fibroblasts and collagen reaction directly, in tendon surrounding tissues and neighbour blood vessels which increase tissue temperature that leads to increase intermediate cells which assist to engorgement debris tissue and provide more fibroblast in the area. The thermo-effect and attractive-effect of magnetic field to blood vessels and blood parameters lead to increase vessels permeability, local blood

circulation in area, therefore increase oxygen supplementation, anabolic matrix, and calcium ions which play role in rapture tendon healing. In bone marrow, the magnetic field stimulate haemopoietic system and increase blood supply to general circulation lead to assist rupture tendon healing. In rabbits, the magnetic field extend to abdominal cavity, when the effect reach to liver and spleen cause an increase blood supply to general circulation, and also increases liver enzymes, some enzymes assist to tendon healing by providing transforming growth factors(TGF). All these factors were documented in researchers, *S. Zara et. al*, *M. Y. El-Ashry et. al.*, and *S. M. Sallam* (25,26 and 27)., which summarized in diagram (fig 10)



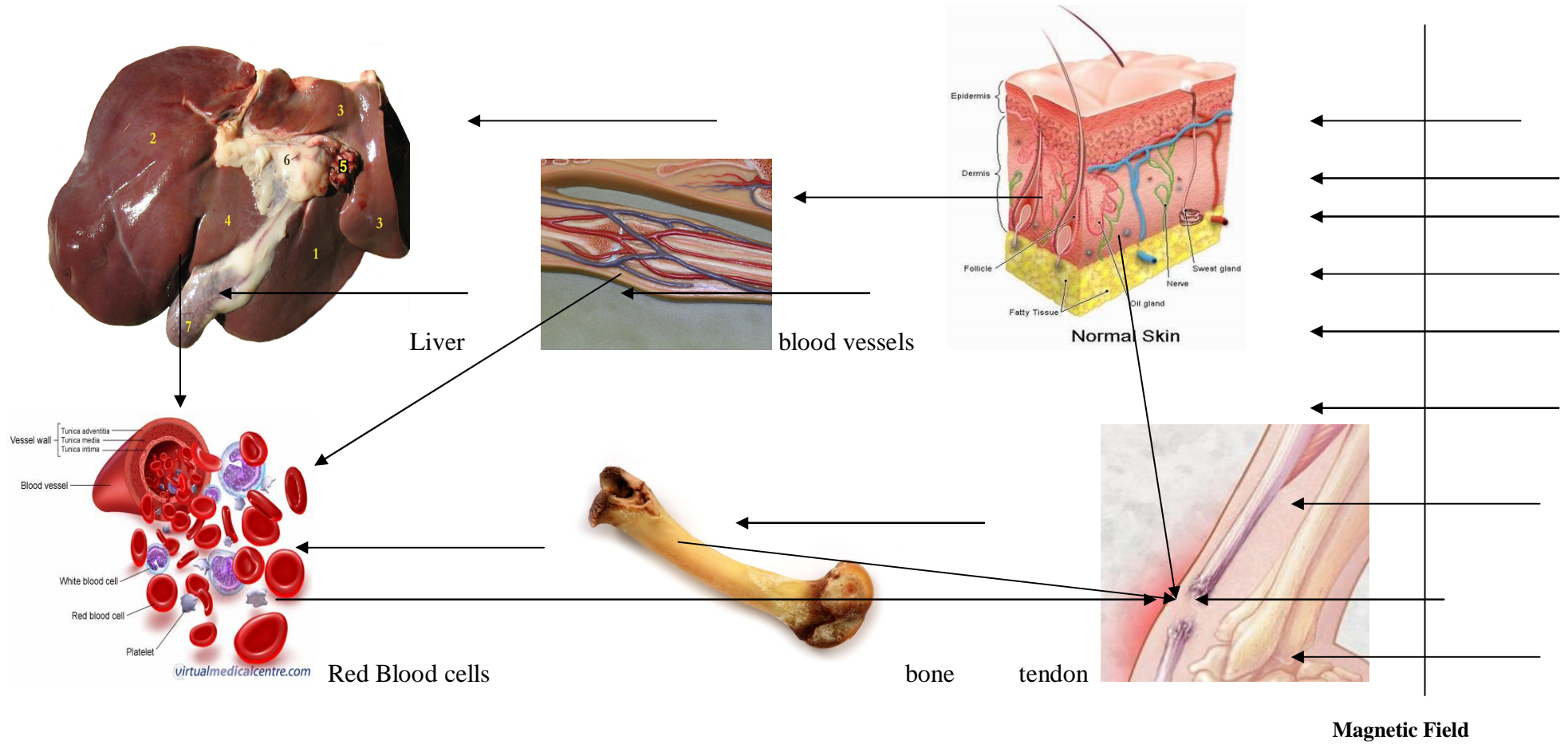


Figure 10: Mechanism Of Magnetic Field Action To Tendon Healing



## References

- 1- P. K. Kannus, P. Paakkala, M. Pasaben and M. Jarvinen, *Am. Sports Med.* 28, 634(2001).
- 2- C. Forslund, *Acta. Orthop. Scan. Suppl.*, 74, 308 (2003).
- 3- A. A. Pilla, Handbook of Biological Effect Electromagnetic, 3<sup>rd</sup> ed. , *Barnesf. Press* 85 (2006).
- 4- M. Benjamin and J. R. Raphs, *J. Anat.*, 12, 1135(1997).
- 5- J. M. Casey, *Am. J. Vet. Res.*, 53,751(2005).
- 6- H. Nasha, *Am. J. Pathol. Teach.* 43,213 (2007).
- 7- A. A. Suchak., C. S. Poorner, D. C. Reid and N. M. Jamha, *Clin. Orthop. Relat. Res.*, 445, 216(2006).
- 8- J. M. Bjordal, R. A. Lope and V. V. Iversen, *Br. J. Spots Med.*, 40, 76(2006).
- 9- K. M. Heinemeier, J. L. Olesen, F. Haddad, P. Schjerling, K. M Baldwin and M. Kjaer, *J. Appl. Physiol.*, 106, 178 (2009).
- 10- T. W. Gilbert, A. M. Stewart, A. S. Byerd and S. F. Badylak, *JBJS*, 89, 621(2007).
- 11- D. A. Degner, *Vet. Res. Cent.*, 46, 515 (2004).
- 12- E. M. Gaughan, A. J. Nixon, L. R. Krook, A. E. Yeager, K. A. Mann, H. Mohammed and D. L. Bartel, *Am. J. Vet. Res.*, 52(2), 764(1991).
- 13- W.R. Walsh, P. Stephens, F. Vizesi, W. Bruce, J. Huckle and Y. Yu, *J. Arthrop. Relat. Surg.*, 32,179(2007).
- 14- L. Jance, N. Cornick and F. Seahorn, *Butter Worth-Heiremann*, USA, 237(2001).
- 15- E. J. Hazan, *Physics q c Lab. Manual, Black-well Sci. Ltd*, California. Davis, CA. USA, 321 (2002).
- 16- F.W. Sears, *Addison-Wesley publishing company*, Amsterdam. UK, 312 (1977).
- 17- F. R. Noyes, S.D. Westin, C. Fleckenstein, C. Walsh and J. West, *Am. J. Sport Med.*, 33, 205 (2005).
- 18- K. Goss, C. Colby, D. T. Kirkendal and D. Robi, *Br. J. Sports Med.*, 34, 293 (2000).
- 19- I. M.H. Alrashid, A. A. Alfaris and C. A. Emshary, *J B Sci* ,35(1) 21 (2009).
- 20- P. E. Steyn, D. W. Ramy and J. Kirschuink, *JAVMA*, 6,217 (2000).
- 21- J. K. Kangas, *herkules oulu.fi/isbn979514284392*(thesis) (2003).
- 22- A. R. Liboff, S. Cherng, K. A. Jenrow and A. Bull, *J. Plast. Rocon. Surg.* ,15, 317(2005).
- 23- S. Zara, H. Hayatgeibi and A. G. Ebadi, *Am. J Biotech.*, 1(4), 217, 2005).
- 24- M. Y. El-Ashry, M. A. Ibrahim and E. A. Ali, *Suez Canal Uni. Med. J.*, 11(1), 53(2008).
- 25- S. M. Sallam and A. M. Awad, *Romania J. Biophys.*, 18(4), 337(2008).
- 26- B. Kula, A. Sobczak, R. G. Bochenek and H. Piskorska, *J.Occup. Health*, 41,177 (1999).
- 27- G. Demsia, D. Vlastos and D. P. Matthopulos, *Sci. Word J.*, 4(52), 48 (2004).

## دراسة مقارنة لتأثير المجال المغناطيسي المتناوب والمستمر على التئام جرح وتر اكيلس في الأرانب

إبراهيم محمد حسن الراشد

فرع الطب الباطني والجراحة/كلية الطب البيطري /جامعة البصرة/ العراق

### الخلاصة

استخدم المجال المغناطيسي المتناوب والمستمر للذين لم يظهر أي فرق معنوي بينهما عند مستوى  $P \geq 0.05$  في علاج وتر اكيلس المقطوع في الأرانب. استخدم ثمانية عشر أرنب من ذكور في هذه الدراسة، قسمت الحيوانات إلى ثلاث مجاميع متساوية، المجموعة الأولى عولجت بالمجال المغناطيسي المتناوب (650 غاوس، 50 هرتز)، المجموعة الثانية عولجت بالمجال المغناطيسي المستمر (650 غاوس)، بينما تركت المجموعة الثالثة كمجموعة سيطرة. أجريت عملية قطع الوتر إلى كل المجاميع ثم خيبت بصفين الصف الأول بالخياطة البسيطة المتقطعة، والصف الثاني بخياطة الحلقة المغلقة، عرضت المجموعة الأولى والثانية إلى المجال المغناطيسي المتناوب والمستمر لمدة أربعة أسابيع من بعد العملية مباشرة. تم تسجيل الإعراض السريرية لكل المجاميع، وأجري اختبار التحمل والقفز المستخدم عند الرياضيين لمعرفة كفاءة الوتر بعد العلاج، أظهرت المجاميع المعالجة بالمجال المغناطيسي فرقا معنويا عند  $P \geq 0.05$  مع مجموعة السيطرة، ولم تظهر أي فرق معنوي بين مجموعتي العلاج المغناطيسي المتناوب والمستمر. تم فحص عناصر الدم لكل المجاميع، فأظهرت مجموعتي العلاج المغناطيسي فرق معنوي  $P \geq 0.05$  خلال فترة العلاج مع مجموعة السيطرة، ولكنها عادت بدون فرق معنوي عند الأسبوع السابع (نهاية فترة التجربة). أظهرت الصور العيانية والنسجية المرضية عند الأسبوع السابع لوحظ التئام شبه تام عند مجموعتي المجال المغناطيسي المتناوب والمستمر بينما لوحظ الخلايا الشوانية والمولدة الليفانية بشكل ملحوظ لمجموعة السيطرة.. استنتج أن العلاج بالمجال المغناطيسي له القابلية على تسريع التئام الوتر المقطوع. تم اقتراح ميكانيكية آلية عمل المجال المغناطيسي نظريا ونوقشت لإيضاح صورة العلاج بالمجال المغناطيسي.