Low energy laser irradiation treatment for second intention wound healing in horses

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Abstract

Low energy helium-neon laser irradiation was administered to full thickness skin wounds (3 cm × 3 cm) on the dorsal surface of the metacarpophalangeal/metatarsophalangeal joints and cranial surface of the tarsocrural joints of eight horses. The effects on wound healing were analyzed statistically. There were no differences ($p > 0.55$) observed in the rate of wound healing between the low energy laser irradiated wounds and the control wounds. There was a significant difference ($p < 0.006$) observed in the rate of healing between the anatomical sites. Tarsal wounds healed more rapidly than fetlock wounds.

Résumé

Traitement au laser de basse énergie pour les plaies de guérison par deuxième intention chez les équins

Un traitement au laser, hélion-néon, de basse énergie, a été administré sur des plaies cutanées (3 cm × 3 cm), de pleine épaisseur, chez huit chevaux. Les plaies se situaient à la surface dorsale des articulations métacarpophalangiennes/métatarsophalangiennes ainsi qu'à la surface craniale de l'articulation tarsocrurale. Les résultats ont démontré qu'il n'y avait pas de différence dans la durée de guérison entre les plaies irradiées au laser et les plaies du groupe témoin ($p > 0,55$). Toutefois, les auteurs ont observé une différence ($p < 0,006$) dans le temps de guérison selon le site anatomique de la plaie. Les plaies dans la région du tarse ont guéri plus rapidement que les plaies de la région du boulet.

(Traduit par Dr Thérèse Lanthier)

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Introduction

There are numerous studies in the veterinary literature describing wound healing on the lower limbs of horses. Most authors are quick to realize and state the importance of understanding the biology of wound healing (1–9). Lower limb wounds represent a serious problem to horses, horse owners, and veterinarians.

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At the present time, it is common practice to allow small and large wounds on the lower limbs of horses to heal by second intention (10–13). Information that leads to a better understanding of the biology and principles of lower limb wound healing will assist in the management of such wounds (14–18).

Several treatments have been tested in the last few years and reported in the veterinary literature (1–3,6,9). To date there is no one treatment that is preferred by all authors. To the contrary, there is support for several different treatments which enhance second intention wound healing (1–3,6,9).

Low energy laser irradiation has been reported to enhance cell division in vitro and to promote wound healing in vivo (19–24). It has been advocated for the treatment of sprain/strain injuries and to enhance wound healing in equine clinical practice (25–27).

Our study was designed to evaluate the healing response of wounds on the dorsal aspect of the metacarpophalangeal/metatarsophalangeal joints (fetlocks) and those on the cranial aspect of the tarsocrural joints (hocks), after they were subjected to low energy laser irradiation. Wound retraction, onset of epithelialization, the rate of second intention wound healing (combination of contraction and epithelialization), the local and/or systemic effect of low energy laser irradiation on second intention wound healing, the percentage of wound healing by contraction, and the production of exuberant granulation tissue were evaluated objectively. The resulting cosmetic appearance was evaluated subjectively.

Materials and methods

Eight mature crossbred horses, six geldings and two mares, were used for this experiment. They weighed between 350–427 kg. All eight horses were dewormed and a complete blood count was done and found normal. For the duration of the experiment, the horses were housed in individual tie stalls and offered a free choice of mixed grass hay. The dorsal/cranial aspect of each fetlock/hock was clipped, surgically prepped, and liberally lavaged with sterile saline to remove any antiseptic residue. The horses were restrained and sedated with xylazine (generic xylazine at a concentration of 100 mg/mL manufactured within The People's Republic of China) at a dose of 1.0 mg/kg body weight. Regional anesthesia was accomplished using 2% lidocaine (generic 2% lidocaine hydrochloride manufactured in The People's Republic of China) infiltrated subcutaneously (at a volume of 10 mL to 12 mL) in a horizontal pattern 1 cm proximal to the anticipated wound site. Full thickness skin sections (3 cm × 3 cm) were removed using sharp dissection around a sterile template centered over the dorsal/cranial aspects of all fetlocks and hocks, creating six

Table 1. Summary of experimental design

Treatment		Nontreatment	
Group I (4 horses) (Left side)	n (Sites)	**Group I (4 horses)** (Right side)	n (Sites)
Front fetlock	4	Front fetlock	4
Hind fetlock	4	Hind fetlock	4
Hock	4	Hock	4
Group IIa (2 horses) (Left and right side)	n (Sites)	**Group IIb (2 horses)** (Left and right side)	n (Sites)
Front fetlock	4	Front fetlock	4
Hind fetlock	4	Hind fetlock	4
Hock	4	Hock	4

wounds on each horse (four fetlock wounds and two hock wounds). Each wound was immediately covered with a sterile nonadhesive bandage to protect the wound and control hemorrhage.

The eight horses were divided into groups I and II. For group I horses, all wounds on the left side (n = 12), i.e. left metacarpophalangeal, left metatarsophalangeal, and left tarsocrural joints, were treated with low energy laser irradiation while all wounds on the right side (n = 12), i.e. right metacarpophalangeal, right metatarsophalangeal, and right tarsocrural joints, were left untreated and functioned as controls. Group II horses were divided in half, group IIa and group IIb. All wounds in group IIa (n = 12) were treated with low energy laser irradiation whereas all wounds in group IIb (n = 12) were designated as controls and left untreated. All individual selections within groups were made randomly (Table 1).

Low energy laser irradiation was administered with a helium-neon laser (Helium - Neon Laser 5, Laser Technique Institute, Harbin, People's Republic of China). The helium-neon laser has a beam diameter (spot size) of 44 mm at a distance of 50 cm. Laser treatment consisted of subjecting the wounds to a loading dose on day 1 and a maintenance dose for the subsequent 10 days. A loading dose of 10–15 milliamps at an output of 13 milliwatts and an electrical pressure of 220 volts was applied to three spots on the wound surface. The spots were positioned at the top medial and lateral corners of the wound and centrally at the bottom of the wound. The laser was administered for three minutes per spot (total of nine minutes per wound). The energy delivered to each spot was 0.085 watts/cm^2, equivalent to 15.3 joules/cm^2. Energy delivered per wound was 45.9 joules/cm^2. Horses in group I (treated left side) received a total body dose of 137.7 joules/cm^2. Horses in group IIa (laser treatment on all six wounds) accumulated a total body dose of 275.4 joules/cm^2. The maintenance dose of 10–15 milliamps at an output of 13 milliwatts and an electrical pressure of 220 volts was delivered for 60 seconds on only one spot, which was aimed at the approximate center of the wound. Therefore, the maintenance wound dose and body dose were 5.1 joules/cm^2 and 15.3 joules/cm^2, respectively, for group I and 5.1 joules/cm^2 and 30.6 joules/cm^2, respectively, for group IIa.

There is some speculation over the mechanism of low energy irradiation, the benefits being either locally or systemically derived (21,22). For that reason, the experiment was divided into two halves to differentiate these effects. First, in group I laser irradiation was administered to half of the wounds on each horse whereas in group IIa laser irradiation was administered to all of the wounds on half of the horses. Therefore, in the first half of the experiment the total body dose was half of that administered in the second half of the experiment.

All wounds (laser treated and nontreated wounds) were cleaned daily using five minutes of hydrotherapy on each wound to remove all scabs and debris. Wounds were evaluated clinically twice weekly, and traced manually using transparent cellulose acetate and a wax pencil. Care was taken to differentiate and record epithelial growth from the full thickness wound edges. Complete wound healing was considered present when the defect had closed by the process of contraction and epithelialization. The height (measured in mm) and shape of the repair tissue within the scar were also estimated and recorded.

The wound areas were calculated from the manual tracings using a digital analyzer. The date were analyzed using the method described by Snowden (28), which utilizes the square root of the area to allow assessment of changes in the linear dimensions of the wounds. Linear regression equations and R^2 (coefficient of determinations) were calculated to assess the changes in the square root of the wound area with time. Analysis of covariance was used to compare the slope of each of the equations. A one-way analysis of a variance was used to compare the laser treated wounds with the control wounds. The cosmetic appearance was evaluated on the basis of subjective measurements and was not evaluated statistically.

Results

The first and most obvious observation recorded on day 1 was wound retraction. The wound areas had increased from their original size of 9 cm^2 to between 10.89–12.13 cm^2 over the dorsal aspect of the fetlocks and from 13.21–14.37 cm^2 over the cranial surface of the hocks. Wounds over the dorsal aspect of the fetlocks did not return to their original size until between days 11 and 15 postwounding, whereas wounds over the cranial surface of the hocks returned to their original size on day 18 to day 22 postwounding.

Epithelium was first noted at the skin margins between day 11 and day 15 postwounding. There were no differences in the time of first observation of epithelium between the front and hind fetlocks or between the combined fetlocks and hocks.

There were no significant differences ($p > 0.55$) between the rates of healing of any of the treated and nontreated fetlock sites or treated and nontreated hock sites. When a comparison was made of the combined data (combined fetlock sites and combined hock sites) of the treated versus the nontreated sites, there was no significant difference ($p > 0.55$). There was, however, a significant difference ($p < 0.006$) between the rate of healing of the combined fetlock sites compared to the combined hock sites. The average time for healing of the hock wounds was 57 days (range 43–71 days), whereas the average healing time for the fetlock wounds was 74 days (range 57–95 days) (Table 2).

There was no significant difference between the low systemic body dose group (Group I) and the high systemic body dose group (Group IIa).

The percentage of wound concentration (expressed as the size of the wound at the time of complete epithelialization/original size of the wound) for fetlocks and hocks ranged from 54% to 65% and 59% to 72%, respectively.

Granulation tissue did not become excessive at any of the treated or nontreated sites.

The cosmetic evaluations indicated that the residual scars over the cranial faces of the hocks exhibited less fibrosis than the scars over the dorsal aspects of the fetlocks both for the treated and nontreated sites. Subjectively, all wounds in the treatment groups appeared less edematous during the first 11 days of the trial while laser irradiation was being administered. However, as previously stated, there were no significant differences in the healing rates.

Table 2. Number of days from wounding to healing

Horse no.	LFF[a]	RFF[b]	LHF[c]	RHF[d]	LH[e]	RH[f]
	Days					
1	95	88	95	88	50	71
2	57	60	74	74	53	60
3	57	85	81	57	57	57
4	60	60	64	64	71	71
5	92	92	78	85	50	50
6	57	60	57	60	71	64
7	92	92	78	85	50	43
8	71	71	71	71	53	50
Mean	**73**	**76**	**75**	**73**	**57**	**58**
Range	**57–95**	**60–92**	**57–95**	**60–88**	**50–71**	**43–71**

[a]LFF left fore fetlock
[b]RFF right fore fetlock
[c]LHF left hind fetlock
[d]RHF right hind fetlock
[e]LH left hock
[f]RH right hock

Discussion

There is evidence in the literature that low energy laser irradiation has a therapeutic effect on wound healing. This assumption, however, is controversial (19–24). The results of our study support the observation that low energy laser irradiation administered at the stated doses neither positively nor negatively affects wound healing.

It has been reported that low energy laser irradiation has an anti-inflammatory effect which decreases edema and reduces the local neutrophilic response (23,29). It is this effect which may have been responsible for the subjective evaluation that laser-treated wounds were less edematous in appearance during the first 11 postwounding days.

It is interesting that we saw no significant differences in the rates of wound healing when comparing group I (half of the wounds on each horse were laser irradiated) to group IIa (all of the wounds on half the horses were laser irradiated). Therefore, the controversy over the local versus systemic effects of low energy laser irradiation still exists (21,22).

Last, it is interesting to note that, regardless of whether treated or not, hock wounds healed more rapidly than fetlock wounds and the hock wounds appeared to contract more than fetlock wounds.

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BOOK REVIEWS

REVUES DE LIVRE

Randall CJ. **Color Atlas of Diseases and Disorders of the Domestic Fowl and Turkey, 2nd ed.** Ames: Iowa State University Press, 1991. 175 pp. ISBN Q-8138-0376-4. $76.95 US plus GST and $6 shipping

This book is a photographic presentation of most infectious and non-infectious diseases of importance in modern poultry production. Although it depicts case material frequently encountered in Great Britain, it has relevance in all countries where poultry is raised, as most diseases are universal in modern poultry environments. Almost all diseases are relevant to Canada.

The purpose and format are identical to those of the 1985 edition. The intent is for the atlas to be a reference source for the poultry disease diagnostician. The 2nd edition is expanded to include 453 color photographs. Some of these cover additional disease conditions, while others are expanded or replaced by better quality specimens. The photos are of superb quality and show gross and histological lesions. The text is kept to a minimum and consists mainly of legends to the pictures. For further discussions on the diseases and etiologies, the reader is provided with textbook references.

The format remains by etiologic classes; ie, bacterial, viral, neoplastic, fungal, parasitic, nutritional, and metabolic; uncertain etiology; and miscellaneous diseases. This causes some problems for the veterinary practitioner who infrequently necropsies birds and needs a reference by organ system. This has been acknowledged and partially addressed in the new edition by including cross-references in the legends to other photos which may show a similar lesion in a given organ but under a different etiology. The practice, however, is not consistent throughout the book and leaves room for improvement.

The following comments on specific photos should not be interpreted as a general downgrading of the book:

#38. "Yolk sac infection". In the reviewer's experience, this photo shows typical sexing injury resulting in rupture of the yolk sac.
#54. This photo is out of focus although the lesion is still visible.
#50. An arrow would be useful to point out the affected hearing valve.
#120. This photo of "Inclusion body hepatitis" is improved over that in the first edition, but the legend lacks reference for differential diagnoses.
#280. "Vitamin A deficiency" does not include a gross photograph.
#284. Differences between "Ca/Vit D and Phosphorus deficiencies" are discussed but no gross photos of bone sections are shown. On the other hand a good example is depicted for tibial dyschondroplasia.

A book of this nature cannot be all encompassing, but it is the best color atlas available and would be of great value to the veterinary practitioner and the student of poultry diseases. For the poultry pathologist, it is a delightful presentation of "favorite" lesions.

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