High-power Photobiomodulation Therapy in the Conservative Management of Two Severe Equine Distal Limb Injuries

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SUMMARY

Distal limb injuries in horses often carry a guarded prognosis due to the frequent involvement of critical anatomical structures such as tendons, synovial sheaths, and hoof capsule. When surgical repair is not feasible because of financial, anatomical, or prognostic constraints, conservative protocols incorporating adjunctive therapies may represent a valuable alternative. Photobiomodulation therapy (PBMT) has recently gained attention as a potential adjunct to support tendon repair and wound healing.

This report describes conservative management of two equine patients with severe distal limb trauma, both treated with a multimodal protocol that included high-power PBMT. The first case was a 7-year-old sport horse with complete laceration of the superficial and deep digital flexor tendons and contamination of the digital flexor tendon sheath. Surgical repair was declined, and the horse received systemic antibiotics, anti-inflammatories, regional limb perfusion, external immobilization, and 30 PBMT sessions over 123 days. The second case was a 5-year-old pony mare with traumatic medial hoof wall avulsion and exposure of the distal phalanx. Management consisted of wound debridement, systemic antibiotics and anti-inflammatories, stall rest, and 35 consecutive daily PBMT sessions.

Both patients showed progressive wound healing without infection, dehiscence, or exuberant granulation tissue. In Case 1, sequential ultrasonography revealed tendon reorganization and healing of the digital flexor tendons, with complete wound closure after approximately two months and return to paddock activity after 12 weeks. In Case 2, wound contraction occurred at an average rate of approximately 1 cm per week during PBMT, with a marked deceleration after discontinuation of laser therapy; complete epithelialization was achieved by day 80. Hair regrowth occurred exclusively in PBMT-treated areas.

These two clinical cases illustrate that high-power PBMT, when combined with standard conservative measures, may support wound healing, tendon repair, and functional recovery in equine distal limb injuries where surgery is not feasible. Although limited by the small number of cases and absence of control, the consistent clinical course and temporal association with PBMT support the potential value of this modality as an adjunctive therapy. Further controlled clinical investigations are warranted to validate these findings and to establish standardized protocols for different equine soft tissue injuries.

KEY WORDS

Equine; tendon laceration; hoof trauma; photobiomodulation; wound healing.

INTRODUCTION

Distal limb injuries in horses may result in severe orthopedic conditions when critical anatomical structures, such as the superficial digital flexor tendon (SDFT), deep digital flexor tendon (DDFT), suspensory ligament (SL), straight sesamoidean ligament (OST), oblique sesamoidean ligaments (OSL), hoof capsule, or others, are involved. Damage of these structures is usually associated with guarded prognosis and prolonged rehabilitation (1).

In particular, complete lacerations of the digital flexor tendons involving the digital flexor tendon sheath (DFTS) carry a poor prognosis due to impaired tendon healing in the synovial environment and a high risk of adhesion formation or septic tenosynovitis (2-5). Similarly, traumatic hoof wall avulsions with exposure of the distal phalanx are associated with prolonged healing times, frequent complications such as infection, granulation tissue formation, and scar contracture, and in some cases lead to euthanasia for welfare reasons (6).

Treatment strategies are strongly influenced by the location and severity of the lesion. Surgical tenorrhaphy within 36-48 hours is considered the gold standard for complete tendon lacerations, especially when extra-synovial, and is usually combined with cast immobilization (4,7). Intra-synovial tendon injuries remain more challenging and often show delayed or incomplete recovery even with surgical repair. In situations where surgery is not feasible due to economic restrictions, delayed referral, or guarded prognosis, conservative protocols can be applied, yet functional outcomes are uncertain (8).

Photobiomodulation therapy (PBMT) has emerged as a promising adjunctive modality for musculoskeletal and soft tissue injuries in veterinary medicine. PBMT exploits red and near-infrared light to stimulate mitochondrial activity, increase ATP synthesis, modulate inflammatory cascades, and promote tissue repair (9). Early studies using low-level laser therapy in equine wounds reported limited results (10), but more recent

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investigations with high-power PBMT demonstrated clinical benefits in tendon healing and soft tissue repair. Retrospective and experimental studies have documented reduced pain and swelling, improved collagen organization, and accelerated lesion contraction following dual-wavelength PBMT (11-14). Nevertheless, reports of application in equine distal limb injuries involving DFTS or hoof wall are lacking.

The aim of this report is to describe conservative management of two equine patients with severe distal limb injuries, in which high-power PBMT with MLS® technology was applied as part of a multimodal therapeutic protocol.

CASES PRESENTATION

Case 1

Signalment and history.

A 7-year-old Italian Saddlebred gelding, used for low-level show jumping, was found non-weight-bearing on the right hindlimb with a wound on the plantar aspect of the proximal pastern. The first veterinarian considered the prognosis poor and recommended euthanasia. After approximately 12 hours, the horse was re-evaluated by a second practitioner, who noted a full-thickness wound with non-weight-bearing lameness at walk and elevation of the toe.

Diagnostic assessment.

Ultrasonographic examination of the area was performed, which showed complete laceration of the SDFT and DDFT at the level of the DFTS, Figure 1 (A1-A2).

Medical management.

Surgical repair was declined due to financial constraints; therefore, a conservative protocol was implemented. The horse was sedated with detomidine (0.02 mg/kg IV) and butorphanol (0.1 mg/kg IV) and restrained with a nose twitch. A plantar low six-point block was performed using 2.5 ml mepivacaine per site. Under aseptic conditions, an ultrasound-guided synoviocentesis of the DFTS was attempted proximal to the plantar annular ligament although no synovial fluid could be retrieved. The sheath was lavaged with 1 L sterile lactated Ringer's solution, and 200 mg gentamicin sulfate was injected intra-synovially.

Regional limb perfusion was performed with a tourniquet placed above the fetlock and a 25-gauge butterfly catheter. A total volume of 60 ml containing 1 g amikacin sulfate was injected into the lateral common digital vein, with the tourniquet maintained for 30 minutes. Four perfusions were carried out on alternate days. Hemorrhage was controlled with tranexamic acid (25 mg/kg IV once daily for three days). Systemic antimicrobials included procaine penicillin (22.000 IU/kg IM twice daily) and gentamicin sulfate (6.6 mg/kg IV once daily). Phenylbutazone (4.4 mg/kg PO once daily) was administered for anti-inflammatory support.

External immobilization was applied using a full-limb Robert Jones bandage combined with dorsal and plantar splints extending to the proximal metatarsus and hock, and heel elevation.

High-power PBMT was initiated on day 1 using an MLS® laser (M-VET, ASA S.r.l., Italy), emitting synchronized 808 nm (continuous/frequency-modulated) and 905 nm (pulsed) wavelengths. The treatment was performed in fixed-point mode with a collimated 2 cm lens (3 cm^2 spot size), covering three zones over the wound and perilesional tissue, Figure 1 (B1-B2).

A total of 30 sessions were performed over 123 days, in conjunction with bandage changes. The first 20 sessions were delivered every 2-4 days, followed by 10 sessions every 4-6 days. During sessions 1-20, each zone received a total dose of 16.52 J/cm^2 (Protocol "*Traumatic wound*": 6.4 J/cm^2 + Protocol "*Deep digital Flexor Tendinopathy*»: 10.12 J/cm^2); from session 21 onwards (after complete wound closure), the dose was reduced to 10.12 J/cm^2. The utilized laser parameters are summarized in Table 1.

No signs of infection were observed during the post-treatment period. The wound progressively contracted and achieved complete closure within approximately 60 days, without dehiscence, purulent discharge, or exuberant granulation tissue formation. After 12 weeks, the external bandage and splints were removed, and a heel extension shoe was applied. Hyperextension of the metatarsophalangeal joint persisted, whereas toe elevation resolved after corrective trimming and shoeing.

Sequential ultrasonographic examinations at 60 and 120 days revealed progressive SDFT and DDFT healing. The sequential clinical and ultrasonographic evolution of the lesion, from the initial presentation to complete recovery, is illustrated in Figure 1 (A-P), showing progressive wound contraction, tendon healing, and restoration of normal limb function by day 97. The horse was gradually reintroduced to paddock turnout (12 hours daily). At day 180, the animal was sound at walk, hyperextension of the fetlock was less obvious, and the pastern appeared slightly thickened.

Case 2

Signalment and history.

A 5-year-old Shetland pony mare presented with a traumatic wound on the medial aspect of the right forefoot and pastern, sustained during turnout. Clinical examination revealed a deep soft tissue laceration with extensive tissue loss, partial detachment of the hoof wall, and exposure of the non-articular surface of the distal phalanx (P3). The pony was markedly lame at walk. The initial wound configuration and tissue loss are illustrated in Figure 2 (A1-A4).

Diagnostic assessment.

Involvement of articular and synovial structures was ruled out by the referring veterinarian during the first examination. Nev-

Table 1 - Laser Therapy - Parameters setting used in case 1.

Protocol applied on each zone	Session N°	Emission Mode	Frequency (Hz)	Intensity (%)	Time (min:sec)	Energy (J)	Dose (J/cm^2)
Traumatic wound	1-20	CPW	-	30	00:14	19.20	6.4
Deep Digital Flexor Tendinopathy	1-30	FPW	292	30	00:53	30.36	10.12

Note: CPW = Continuous Pulsed Wave; FPW = Frequency Pulsed Wave

Figure 1. Case 1 - Sequential clinical and ultrasonographic evolution of a complete digital flexor tendon laceration treated with PBMT.

(A1) Initial presentation (day 0) showing full-thickness wound on the plantar aspect of the right hind pastern; (A2) transverse ultrasonographic image of the plantar aspect of the pastern at the corresponding level, demonstrating complete rupture of the superficial and deep digital flexor tendons within the digital flexor tendon sheath. (B1-B2) Initiation of photobiomodulation therapy (day 2) with an MLS® laser system (M-VET, ASA S.r.l., Italy), with fixed-point application over three treated zones. (C-L) Sequential clinical follow-up from day 4 to day 49 illustrating progressive wound contraction and maturation of granulation tissue. (M-N) Day 59: complete epithelialization without exuberant granulation tissue, and transverse ultrasonographic evidence of partial tendon healing of the plantar pastern. (O) Day 97: full functional recovery with normal weight bearing on the affected limb. (P) Day 124: transverse ultrasonographic follow-up of the plantar pastern showing advanced healing of the digital flexor tendons.

ertheless, hoof wall detachment, bone exposure and high contamination risk lead to a guarded prognosis.

Medical management.

The wound was immediately carefully debrided and protected with a sterile bandage. Anti-inflammatory therapy was administered with phenylbutazone (4 mg/kg PO SID) for seven days, while antimicrobial therapy was provided with a combination of procaine penicillin (22.000 IU/kg IM twice daily) and dihydrostreptomycin (11.25 mg/kg IM twice daily) for ten days. Local care consisted of daily inspection and regular bandage changes for the first 15 days.

To minimize the risk of further trauma and contamination, the pony was confined to a stall with deep bedding throughout the initial healing phase.

Table 2 - Laser Therapy - Parameters used in case 2.

Protocol applied on each zone	Session N°	Emission Mode	Frequency (Hz)	Intensity (%)	Time (min:sec)	Energy (J)	Dose (J/cm²)
Traumatic wound	1-35	CPW	-	30	00:14	19.20	6.4

Note: CPW = Continuous Pulsed Wave.

MLS® PBMT therapy was initiated on day 1. Treatments were performed daily for 35 consecutive sessions, using a collimated 2 cm lens in fixed-point mode, covering five zones along the coronet and pastern as shown in Figure 2 (A2-A3).

Each session delivered an energy dose of 19.2 J (6.4 J/cm²) per zone in continuous pulsed wave (CPW) mode, intensity 30%, with an exposure time of 14 seconds per zone, as reported in Table 2.

The wound was monitored clinically and photographed weekly with the aid of a metric reference. Progressive contraction and granulation tissue formation were observed, with the wound surface remaining flat and parallel to surrounding tissue. By day 35, the lesion showed near-complete closure of the deepest areas and a healthy granulation bed, with an average wound margin reduction of approximately 1 cm per week. Pain decreased progressively, and lameness improved markedly.

After PBMT discontinuation, healing clearly slowed, with the wound-margin reduction rate dropping to roughly half of the previous weekly progression. At day 45, lameness was still present, therefore radiographic examination was performed, showing persistent detachment of a hoof wall segment. The detached portion of hoof wall was surgically removed, leading to rapid improvement of the gait.

Complete epithelialization was achieved by day 80. Hair re-

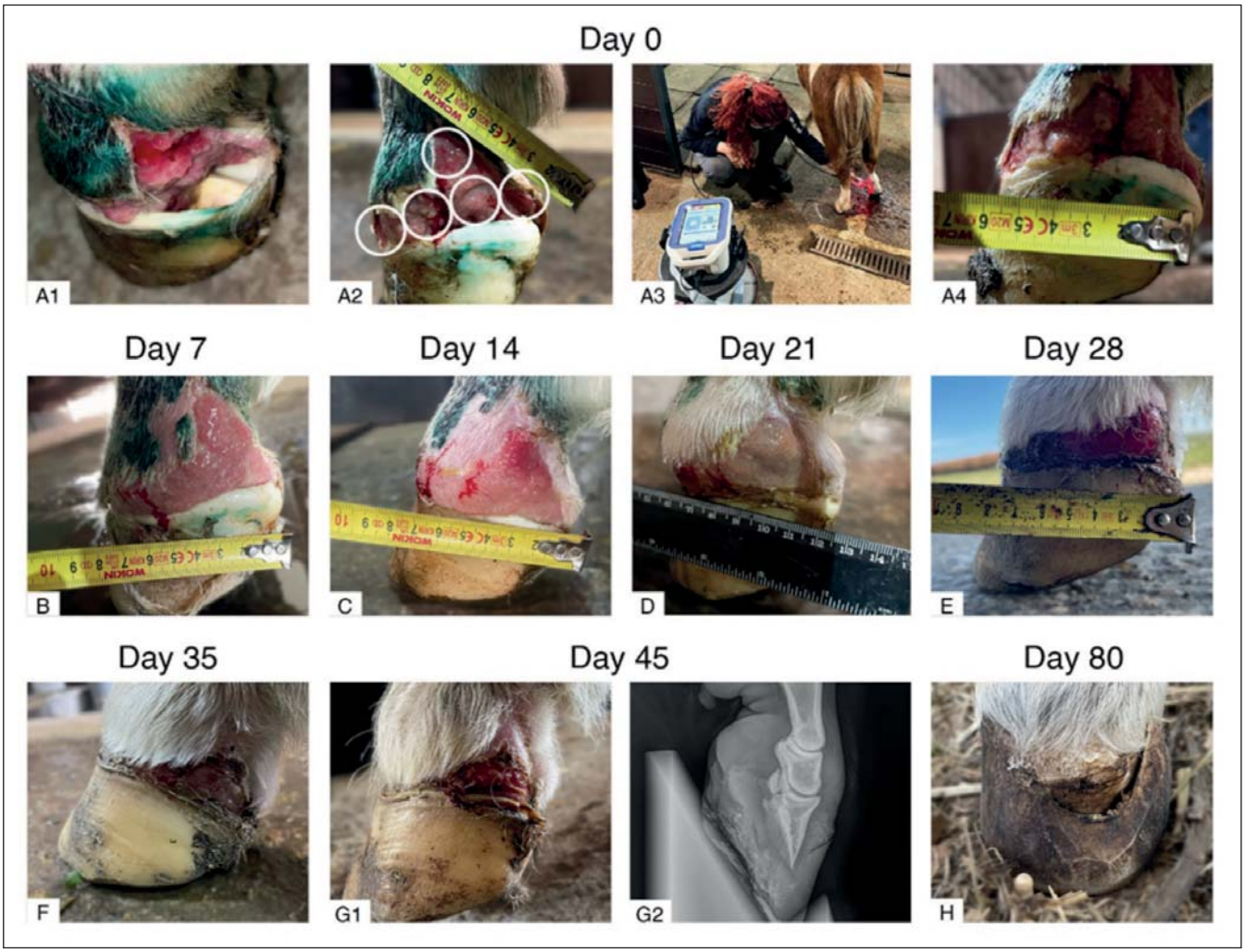

Figure 2. Case 2 - Sequential clinical evolution of a medial hoof wall avulsion with distal phalanx exposure treated with PBMT. (A1-A4) Initial presentation (day 0) showing a deep medial hoof wall avulsion with full-thickness tissue loss and exposure of the non-articular surface of the distal phalanx (P3). The treatment plan included daily photobiomodulation therapy (PBMT) using an MLS® laser system (M-VET, ASA S.r.l., Italy), as illustrated in A2-A3. (B-E) Follow-up from day 7 to day 28 demonstrating progressive wound contraction and development of healthy granulation tissue, monitored with metric measurements. (F) Day 35: near-complete wound closure after 35 consecutive PBMT sessions, with the wound surface level with the surrounding tissue. (G1-G2) Day 45: radiographic examination confirming persistence of a detached hoof wall segment prior to surgical removal. (H) Day 80: complete epithelialization and full hoof wall regrowth with no infection or exuberant granulation tissue.

growth was observed only in PBMT-treated areas, whereas alopecia persisted in untreated wound margins. The sequential clinical progression of the lesion and the response to PBMT, from initial presentation to complete epithelialization, are illustrated in Figure 2 (A-H). No complications such as infection, exuberant granulation tissue, or scar contracture occurred during healing. The pony returned to its pre-injury lifestyle, with unrestricted turnout and physiological movement.

DISCUSSION

This case series describes the conservative management of two severe equine distal limb injuries in which surgical treatment was not feasible. Despite the anatomical and pathological differences both patients achieved wound closure, absence of infection, and functional recovery.

Debridement, surgical tenorrhaphy, wound closure and cast immobilization for at least six weeks is considered the optimal treatment for complete tendon lacerations, due to the higher success rate compared to conservative treatment (1, 22). Moreover, involvement of the DFTS would also require surgical management with tenoscopic lavage to reduce long term complications (5). Nevertheless, surgical approach is not always accepted by the owner for economical or other reasons, as happened in case 1. Therefore, a combination of systemic and regional antimicrobials, anti-inflammatories, external immobilization, and early PBMT was used to improve the outcome. In fact, laser therapy has been demonstrated to accelerate and improve tendon healing in experimentally transected tendons in rabbits (24), whereas in humans it is reported to reduce pain and increase passive range of motion when applied after surgery (23). Thus, PBMT may have contributed to enhancing tendon healing in Case 1.

Some authors suggested a better outcome may be achieved in hindlimbs for this kind of lesions (3), which might have been a favorable prognostic factor in our case, although others report differently (1). Interestingly, as previously reported and similarly to our case, lacerations of both SDFT and DDFT have better prognosis than involvement of only one (3), although other authors have reported otherwise (1). Jordana et al (1) reported higher risk of permanent hyperextension of the fetlock in not-sutured flexor tendons, yet in our case, although it was obvious after the injury, it improved.

Extensive dermal and hoof wall trauma with exposure of distal phalanx (P3) is frequently associated with chronic infection, delayed epithelialization, and prolonged lameness (6). In Case 2, daily PBMT appeared to support faster wound contraction and epithelialization, as indicated by an average wound margin reduction of approximately 1 cm/week during treatment. This value exceeds the cutaneous repair rate reported in ponies, where contractions have been described at around 0.63 cm/week for metatarsal wounds (28). It should also be acknowledged that ponies naturally exhibit faster cutaneous healing dynamics than horses, with greater rates of contraction and epithelialization (29), which may have partially contributed to the favorable trajectory observed. Nevertheless, healing slowed markedly once PBMT was discontinued, reinforcing the hypothesis that photobiomodulation may have contributed to the regenerative process, although further studies are needed to confirm this effect.

Complete avulsions of the foot wall typically require three to six months to heal when surgical repair is not feasible due to tissue loss (25), whereas Case 2 full wound closure was achieved within approximately 80 days. Despite successful epithelization, surgical removal of the detached hoof wall remains necessary in such cases to alleviate pain and ensure the growth of a healthy, structurally functional hoof capsule (27).

Hair regrowth restricted to laser-treated areas further suggests a role in enhancing tissue quality, as previously reported in studies on fibroblast activation and extracellular matrix remodeling (11,13). Improved wound healing and hair growth have also been documented in murine models (26).

Neither case developed infection. In Case 1, synovial structures were at risk of contamination, yet no septic complications occurred, likely due to the combined effect of lavage, systemic and regional antimicrobial therapy, and PBMT. The laser's anti-inflammatory and bio-stimulatory actions, described in both experimental and clinical studies (9,11-14), may have further helped maintain a favorable local environment for tissue repair.

At cellular level, dual-wavelength PBMT has been shown to modulate inflammation and stimulate mitochondrial metabolism, with increased ATP synthesis and improved collagen organization (9,11-13). These mechanisms are consistent with the clinical observations reported here, in which both tendon repair and dermal healing appeared to progress more rapidly than typically expected.

The main limitation of this report is the small number of cases. Objective measures of tissue healing, such as standardized wound scoring or histopathology, were not available. Furthermore, the contribution of PBMT cannot be isolated from other components of the multimodal protocol.

CONCLUSIONS

The two cases presented here document the integration of high-power MLS® photobiomodulation therapy into conservative treatment protocols for a complete digital flexor tendon laceration and a traumatic hoof wall avulsion with distal phalanx exposure. In both patients, progressive wound closure, absence of infection, and return to functional use of the limb were achieved despite the guarded prognosis and the lack of surgical repair.

The temporal association between PBMT and clinical improvement, together with biologically plausible mechanism supported by experimental work on tendon and dermal repair, suggests that high-power PBMT may have contributed to enhancing both tendon and soft tissue healing in these horses. However, the small sample size, lack of objective outcome measures, and concurrent use of standard therapies preclude any definitive conclusions regarding causality.

These observations nonetheless provide a rationale for further controlled clinical studies aimed at validating the efficacy of PBMT as an adjunct to conservative or surgical management and at defining standardized treatment protocols for equine musculoskeletal and soft tissue injuries affecting distal limb.

Authors' Contributions

Conceptualization and funding acquisition: I.G., D.T. Methodology, patients' treatment and data collection: I.G. Data curation, writing-review, editing, supervision: I.G., G.F, D.T. Writ-

ing-original draft preparation: I.G., G.F. All authors have read and agree to published version of the article.

Conflict of interest statement

D.T. is employed by ASA S.r.l. The remaining authors declare that the research was conducted in the absence of any commercial or financial relationship that could be construed as a potential conflict of interest.

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