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Efficacy of low level Gallium-Arsenide laser therapy in conjunction with therapeutic hoof trimming for the treatment of sole ulcer in dairy cattle#

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Abstract

The study was conducted in postpartum lactating dairy cows to evaluate the healing of sole ulcers using Gallium-Arsenide (Ga-As) laser therapy in combination with therapeutic hoof trimming. Thirty-five clinically lame cattle were examined, of which seven animals presented with sole ulcers confined to a single hind limb claw were selected for the study. Therapeutic hoof trimming was performed under standing sedation, followed by application of wooden hoof blocks and bandaging with 10 per cent zinc oxide ointment. Low level laser therapy (650 nm, 4 J/cm^2) was applied once daily for three consecutive days. Marked improvements were observed in wound healing, granulation tissue quality, pain sensitivity and locomotion. In conclusion, Ga-As laser therapy in combination with therapeutic hoof trimming significantly enhanced sole ulcer healing, reduced pain and restored normal locomotion in dairy cattle.

Keywords*: Sole ulcer, therapeutic hoof trimming, low level laser therapy*

Sole ulcer is one of the most prevalent claw disorders in dairy cattle resulting from excessive pressure on the sole corium due to poor claw conformation (Shearer et al*.,* 2015). This painful condition compromises animal welfare, reduces milk production, and negatively affects reproductive performance (Sadiq et al*.,* 2021). Conventional management involves therapeutic hoof trimming, hoof block application and supportive therapy (Buisman et al., 2018). However, healing is often prolonged and lameness may persist till healing of sole ulcer. Low level laser therapy (LLLT) has been introduced as a supportive treatment for wound healing and pain management. By stimulating fibroblasts, macrophages and growth factor release, LLLT promotes collagen synthesis, angiogenesis and tissue repair (Mirsky et al*.,* 2002). Low level laser therapy has been used by Sellera et al. (2013) along with a photosensitiser for the healing of toe ulcer in dairy cattle and reported better results. However, the effect of LLLT on healing of sole ulcers is not studied yet. Hence, this study was undertaken to evaluate the effect of Ga-As diode laser therapy combined with therapeutic hoof trimming for the healing of sole ulcers in dairy cattle.

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Materials and methods

The study was conducted at the University Livestock Farm and Fodder Research and Development Scheme, Mannuthy and mini dairy units in and around Thrissur. Out of 35 lame cows examined, seven were diagnosed with sole ulcers confined to a single hind limb claw and were selected for the study. Signalment and anamnesis of selected lame animals including identification number, breed, age, parity, stage of lactation and previous treatment if any were recorded. Physical examination like assessment of body condition score (BCS) was performed as per Philip et al. (2022a) and lameness score as per Sprecher et al. (1997) were done. Lameness scoring was done at a five days interval up to 60 days. Claw health indicators and claw dimensions were assessed (Abhiram et al., 2022) and severity of sole lesion were scored (Kofler et al., 2011). Therapeutic hoof trimming was performed under modified standing sedation using butorphanol tartarate (0.01 mg/kg), xylazine hydrochloride (0.01 mg/kg) and ketamine hydrochloride (0.02 mg/kg) as recommended by Philip et al. (2022a). Wooden hoof blocks were applied to the unaffected claw to relieve weight from the lesion and ulcer site was bandaged with 10 per cent zinc oxide ointment. LLLT was initiated 24 hours after therapeutic hoof trimming using a Gallium-Arsenide (Ga-As) laser with wavelength of 650 nm (Digi laser pro®, BMS, Chennai) at 4 J/cm^2 and was applied once daily for three consecutive days (Reji et al., 2023). Physiological parameters and haematological values were recorded at five-day intervals till 25th day after therapeutic hoof trimming. Wound planimetry was conducted on day 0 and every five days up to 25th day of observation in order to calculate the wound closure. The percentage of wound closure was estimated using the formula described by Anjum et al. (2023). Wound appearance was evaluated every five days up to the 25th day of observation, based on a three-point scoring system assessing the colour, quality and protuberance of granulation tissue. Pain sensitivity was assessed concurrently using a four-point scoring system described by Karthik (2023) at five-day intervals till 25th day after therapeutic hoof trimming.

Results and discussion

The cows selected in the study were between three and six years of age, with 57 per cent in early lactation, and 86 per cent of animals belonged to crossbred Holstein Friesian indicating a higher susceptibility of Holstein Friesian to sole ulceration (Anees et al., 2022). The risk of developing sole lesions is higher during early lactation, likely due to thinning of the digital cushion that occurs before and shortly after calving (Griffiths et al., 2020). Most animals were in their second or third parity (42 per cent each). These findings were in agreement with Karthik (2023), who reported that cattle above three years of age and with more than two calvings were at a greater risk of developing sole ulcers. On physical examination, even with a mean body condition score of 2.86 ± 0.26, the animals were affected with sole ulcer, suggesting that factors beyond body condition, such as claw conformation and stage of lactation, may play a more critical role in its occurrence. This was in accordance with the findings of Abhiram et al. (2023) and Karthik (2023), who reported a mean body condition score of 2.5 in cattle diagnosed with sole ulcers. A mean lameness score of 3.71 ± 0.29 was observed in the present study and was in agreement with Anees et al. (2022) who reported a mean value of four in animals affected with sole ulcer. Claw health indicators revealed median scores of two for claw angle, hock angle, hock wound, and rear leg set, indicating moderate conformational deviations. The affected claws exhibited increased toe height (6.77 ± 0.12 cm) and claw diagonal (12.90 ± 0.28 cm) compared to ideal values, while claw angle was significantly reduced (35.57 ± 1.93 degrees). These findings highlighted the association between poor claw conformation and development of sole lesions (Sasidharan et al., 2019). Lesions were confined to zone 4 of the claw with a mean lesion score of 2.47, indicating a moderately severe lesion with wound diameter between 1.0 cm and 2.5 cm (Fig. 1).

Physiological parameters such as rectal temperature and respiratory rate declined significantly from day zero to day 25, while rumen motility showed marked improvement. This may be due to the decreased stress of the animal along with the healing of the sole ulcer (Saikiran et al., 2023; Jung et al., 2024). Haemoglobin, volume of packed red cells and total erythrocyte count showed significant increase on comparison between day zero and day 25 which may be due to the increased feed intake and animal comfort following therapeutic hoof trimming as observed by Philip et al. (2022b). Other haematological parameters remained stable during the period of

Fig 1. Day 0

Fig 2. LLLT being performed

Fig 3. Day 5

Fig 4. Day 20

Table 1. Visual assessment and scoring of wound appearance between days in dairy cattle with sole ulcer (n=7)

Character	Score	5th day		10th day		15th day		20th day		25th day	
		Number of animals	Per cent	Number of animals	Per cent	Number of animals	Per cent	Number of animals	Per cent	Number of animals	Per cent
Colour of granulation tissue	1	4	57.14	1	14.28	0	0	0	0	0	0
	2	3	42.86	2	28.58	2	28.58	1	14.28	0	0
	3	0	0	4	57.14	5	71.42	6	85.72	7	100
Median		1		3		3		3		3	
Quality of granulation tissue	1	4	57.14	4	57.14	5	71.42	6	85.72	7	100
	2	3	42.86	3	42.86	2	28.58	1	14.28	0	0
	3	0	0	0	0	0	0	0	0	0	0
Median		1		1		1		1		1	
Protuberance of granulation tissue	1	2	28.58	4	57.14	5	71.42	7	100	7	100
	2	3	42.84	2	28.58	2	28.58	0	0	0	0
	3	2	28.58	1	14.28	0	0	0	0	0	0
Median		2		1		1		1		1	

observation (Vijayaraghavan, 2024). Moderate to severe sole ulcers typically require 30 to 40 days for complete healing, even after therapeutic hoof trimming. To overcome this limitation, low level laser therapy was employed in the present study (Fig. 2), as it enhances mitochondrial activity, stimulates angiogenesis and promotes cellular repair at the wound site. These effects accelerate granulation tissue formation and wound contraction and as a result, healing progressed much faster in the treated animals (Fig. 3 and 4). The visual assessment of the wound appearance revealed a rapid improvement in the quality of granulation tissue. In the present study, the median score for the colour of granulation tissue showed score 1 indicating red colour granulation tissue on 5th day to score 3 by day 15 and remained at score 3 thereafter, indicating steady improvement from healthy granulation to new horn formation. The median score for granulation tissue quality was consistently score1 throughout the observation period, indicating firm and regular tissue formation. In case of median score for protuberance the score decreased from 2 on day 5 to score 1 by day 10 indicating an absence of protuberance and remained at score 1 until day 25, indicating an organization of the wound surface as healing progressed (Hodjati et al*.,* 2014). (Table 1).

Complete closure of the wound was achieved within 20 days. Similar observation was made by Nekha et al. (2021) in which she studied healing of cutaneous wounds using Ga-As laser at 4 J/cm^2 in diabetic rat models and reported a complete closure of the wound in two weeks.

The healing time in the current study was less than the healing time of Abhiram (2022) and Karthik (2023), who reported healing by 26th and 22nd days after using regenerative therapies for the healing of sole lesions respectively, indicating the added benefit of low level laser therapy.

Pain sensitivity decreased markedly from 5th day and was absent after day 15, which may be due to the analgesic effect of LLLT. These findings were consistent with Petermann (2011) who compared the pre and post treatment pain scores of 21 horses treated for laminitis with low level laser therapy and reported a significant reduction in pain following treatment (Table 2).

Locomotion scores improved significantly, with all animals returning to normal gait by day 20. This was in accordance with Pooja et al. (2025) who studied the effects of LLLT on wound healing and quality of life in foot ulcers of human beings and reported that LLLT not only accelerated wound healing but also contributed to functional recovery, including improved gait and mobility, similar observations were made by Passos et al., (2017) who reported functional hoof trimming and appropriate treatment improved locomotion in lame animals. In the present study, the improvement in locomotion achieved was sustained up to 60th day without any signs of recurrence (Table 3).

Table 2. Comparison of pain sensitivity between days in dairy cattle with sole ulcer (n=7)

Day	Mean	SE	Median
0	4.00	0	4^a
5	1.95	0.26	2^b
10	1.42	0.20	1^c
15	1.28	0.18	1^c
20	1	0	1^c
25	1	0	1^c
χ^2 Value = 35.00**; (p < 0.001)			

*** Significant at 0.01 level on Friedmann's test followed by pairwise comparison. Superscript with different alphabets differ significantly.*

Table 3. Comparison of lameness score in days in dairy cattle with sole ulcer (n=7)

Day	Mean	SE	Median
0	3.71	0.22	4
5	3.29	0.18	3
10	2.86	0.26	3
15	2.00	0.22	2
20	1.14	0.14	1
25	1	0	1
30	1	0	1
60	1	0	1
χ^2 -Value = 38.00**; (p < 0.001)			

Significant at 0.01 level on Friedmann's test followed by pairwise comparison. Superscript with different alphabets differ significantly

No complications were observed during the study

Conflict of Interest

The authors declare that they have no conflict of interest.

Conclusion

Low level laser therapy with a Ga-As diode laser (650 nm) at 4 J/cm^2 combined with therapeutic hoof trimming, promoted faster healing of sole ulcers by healing wounds quickly, reducing pain, and improving recovery, which in turn enhanced both productivity and animal welfare.

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