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Modified Z-bar shoe eliminates occasional frog bruising accompanying Z-bar shoeing for navicular syndrome management in underrun-heeled horses

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Two horses diagnosed with underrun heels leading to navicular syndrome were fitted with Z-bar shoes. They occasionally showed moderate lameness on the affected legs after the sixth and tenth consecutive farrier adjustments. The affected hooves were sensitive to compression of the frog and sole in their palmar regions. Modified Z-bar shoes were created and shod on the lame legs based on previous with regional anaesthesia and recent clinical examination. The lameness scores were slightly improved at the first shoeing with the modified Z-bar shoes but were markedly improved at four and eight weeks aftershoeing, without medication. The modified Z-bar shoes in this report could potentially protect the palmar structure damaged by usual Z-bar shoes and contribute to reducing pathogenic impacts deriving from underrun heels and navicular syndrome.

Key words: *frog bruising, horse, modified bar shoe, underrun heel*

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Underrun heels, also known as collapsed heels, are heels with a broken-back hoof-pastern axis that have a hoof wall angle lower than the pastern angle [5]. The caudal portion of the hoof wall bends cranially, resulting in a marked lowering of the angle of the caudal hoof wall relative to the cranial hoof wall [3, 5, 16]. The predisposing cause of underrun heels is mechanical overloading of the palmar region, leading to dorsal displacement of the caudal hoof wall and, in turn, tubular deformation [8]. Furthermore, increased weight-bearing of the palmar region causes compression of the navicular apparatus, resulting in navicular bone degeneration [12]. In addition, osteophytes and enthesophytes of the navicular bone may form as a result of injury of associated ligaments [17]. Accordingly, underrun heels could be directly involved in navicular syndrome [5]. Navicular syndrome is a common cause of chronic lameness and has a long-term impact on a horse's exercise performance [11, 14]. In this syndrome, chronic foot pain is due to repeated grinding injury caused by the navicular bone grinding against the deep digital flexor tendon [18] or damage to associated structures such as the collateral sesamoidean ligament and distal sesamoidean impar ligament [4]. The recommended navicular syndrome management consists of rest, controlled exercise, medical treatment, and shoeing [10, 14]. The use of an egg bar shoe has been reported for the treatment of navicular syndrome and its associated foot pain [6, 10].

The Z-bar shoeing method has recently been proposed as an alternative method to alleviate foot pain caused by navicular syndrome. This shoeing method is designed based

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on previous examinations with regional anaesthesia of the lame leg to localize the palmar pain [2]. However, complications, including frog bruising resulting from compression of the frog's palmar region, occasionally develop following this procedure in horses with underrun heels. An alternative shoeing method should be created to avoid this complication and preserve the effectiveness of navicular syndrome management. This report describes horses suffering occasional bruising of the frog area following the previous style of Z-bar shoeing and application of a modified bar shoe to solve the problem.

Two show-jumping horses (geldings; 430 and 450 kg; 22 and 23 years old) suffered from chronic intermittent lameness, scoring 3 out of 5 on the scale designed by the American Association of Equine Practitioners (AAEP) [1]. A gait analysis was performed according to a method described previously [14]. Horse 1 exhibited underrun heels (Fig. 1a, 1b) and showed lameness in the left forelimb. Horse 2 also exhibited underrun heels (Fig. 1d, 1e) as well as lameness in the right forelimb. The horses were sensitive to hoof test compression in the medial palmar regions of the affected feet. They also responded positively to a navicular wedge test on their lame legs. The results of regional anaesthesia with 2% lidocaine hydrochloride solution indicated medial palmar foot pain in both horses. The differential diagnosis consisted of navicular syndrome, corn, and osteitis of the affected palmar region. Radiography revealed evidence of navicular bone degeneration. In horse 1, a radiolucent area indicating synovial invagination was observed in the navicular bone (Fig. 1c), and horse 2 demonstrated osteophyte formation suggesting navicular bone inflammation (Fig. 1f). Therefore, the horses were diagnosed with navicular syndrome. They were then fitted with Z-bar shoes on the affected feet at four-week intervals according to a method described previously [2]. The Z-bar shoe was designed to place the central straight bar over the entire frog to avoid weight-bearing in the affected palmar area (Fig. 2a). The horses had otherwise been healthy, and they demonstrated a marked improvement in foot pain after Z-bar shoe fitting. Furthermore, they engaged in light- to moderate-intensity exercise comprising trotting and light cantering for 45–60 min a day, three or four days a week, before showing signs of lameness. Unfortunately, both horses showed unexpected moderate pain (a score of 3 for lameness) after this period of exercise. Horse 1 demonstrated foot pain in the left forelimb before the eleventh farrier adjustment, whereas horse 2 showed lameness in the right forelimb before the seventh farrier adjustment. After removing the Z-bar shoes, the portion of the frog over which the central bar of the Z-bar shoe passed was found to be soft and very sensitive to compression (Fig. 2b). Hoof testing revealed that the frog was susceptible to compression. A palmar digital nerve block was then performed on the lame legs of the horses using 2% lidocaine hydrochloride solution, which improved the lameness score to <1 when trotting off. We diagnosed that the two horses suffered frog bruising due to frog compression caused by the shoe's middle bar.

We created a modified Z-bar shoe to eliminate compression of the injured frog and the previously affected palmar areas of each horse. Briefly, a custom metal shoe (Mustadfors Bruks, Dals Langed, Sweden) was cut at the midpoint of the quarter region on the medial side to free the palmar area of concern. The cut branch of the metal shoe was welded internally with another piece of metal parallel to the medial palmar hoof wall to avoid concussion of both the currently injured frog and the previously affected palmar region (Fig. 3a, 3e). Before shoeing, the affected hooves were trimmed, particularly in the palmar area (Figs. 3b, 3f). Horse 1 was then shod with the modified Z-bar shoe on the front left hoof (Fig. 3c, 3d), and horse 2 was shod with the modified Z-bar shoe on the front right hoof (Fig. 3g, 3h). The healthy feet were shod with custom metal shoes according to the fundamental shoeing protocol [13]. The horses were routinely shod with modified Z-bar shoes at four-week intervals, and lameness was evaluated at four and eight weeks after shoeing. The gaits of both horses were recorded with a digital camera (Samsung Galaxy J7, Samsung Electronics, Suwon, South Korea) and later evaluated by five equine veterinarians. The mean lameness scores of each horse were reported before shoeing, immediately after shoeing, four weeks after shoeing, and eight after shoeing with the modified Z-bar shoe. Improvement was observed after shoeing with the modified Z-bar shoe (Fig. 4). Namely, before shoeing, the average lameness score for each horse was approximately 3. Lameness was slightly improved in both horses, with a score of approximately 2 immediately after the application of this specific shoe. Furthermore, the score progressively improved in both horses to <1 at four and eight weeks after shoeing with the modified Z-bar shoe.

The ultimate goals of management for underrun heels are to allow for normal hoof conformation and restore the hoof mechanism and function [5]. Proper trimming of the hoof wall plays a vital role in preventing the collapse of horn tubules and provides for typical conformation of the hoof capsule, including the hoof wall angle, balance, and orientation of the entire hoof [7, 9]. The egg bar shoe was thought to diminish the loading on the solar surface of the foot. However, the lever effect due to the backward extension of the shoe may cause more loading on the palmar region and possibly aggravate the hoof problem [8]. Various types of shoes, including heart-bar shoes, straight-bar shoes, and wide-webbed onion-heel shoes, have been implemented to tackle this problem. Nonetheless, therapeutic protocol success cannot rely solely on

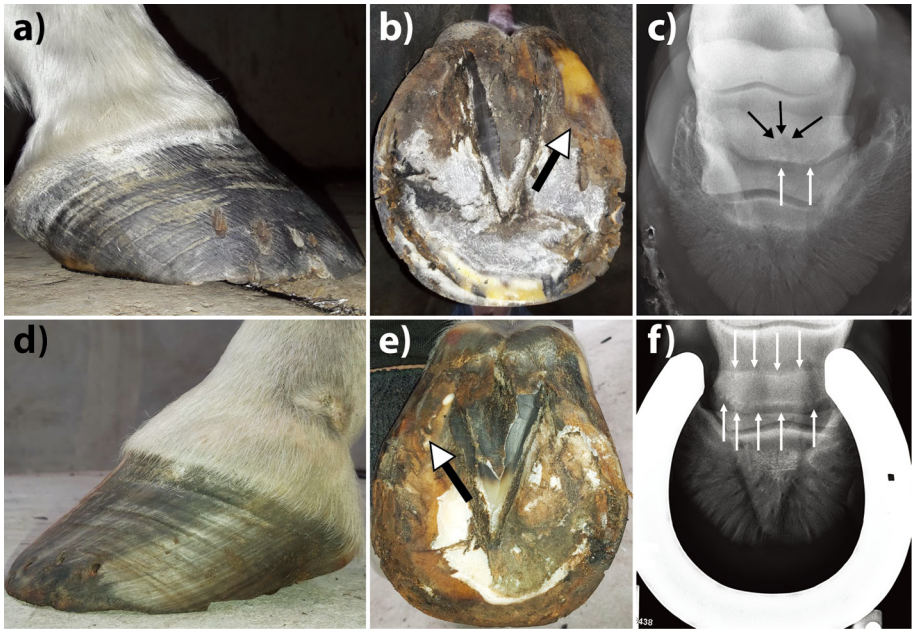

Fig. 1. Poor hoof conformation and the radiographic features of the affected hooves. An underrun heel conformation was observed in the left forelimb of horse 1 (a) and the right forelimb of horse 2 (d). The solar surfaces of the hooves in horse 1 (b) and horse 2 (e) exhibit collapsed heels, particularly in the medial palmar regions (white arrowheads). The radiographic images illustrate that horse 1 showed a cyst-like lesion (black arrows) and irregularly shaped distal border (white arrows) of the navicular bone (c), while horse 2 showed irregularly shaped proximal and distal edges of the navicular bone (white arrows) (f).

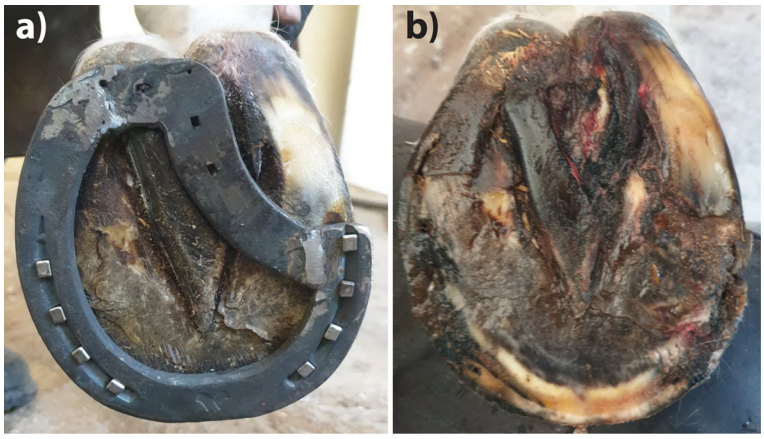

Fig. 2. Z-bar shoeing and frog bruising complication. The affected hoof was shod with the previous style of Z-bar shoe (a). The frog bruising accompanied Z-bar shoeing due to compression of the frog region (b).

hoof management. A controlled exercise program, dietary management, hoof care, and the type of ground surface must also be considered [5]. Meanwhile, shoeing methods for navicular syndrome management have also been previously reported, including the use of an egg bar shoe [6, 10] and shoeing with a 3° heel elevation [15], but these methods were only partially successful. The original Z-bar shoe for navicular syndrome management was designed to prevent concussion of the affected palmar region based on previous examinations with regional anaesthesia. Although the Z-bar shoe might alleviate foot pain and thereby improve exercise performance, it could damage the frog if the horse has poor hoof conformation. Furthermore, frog bruising complications occasionally accompanied the previous style of Z-bar

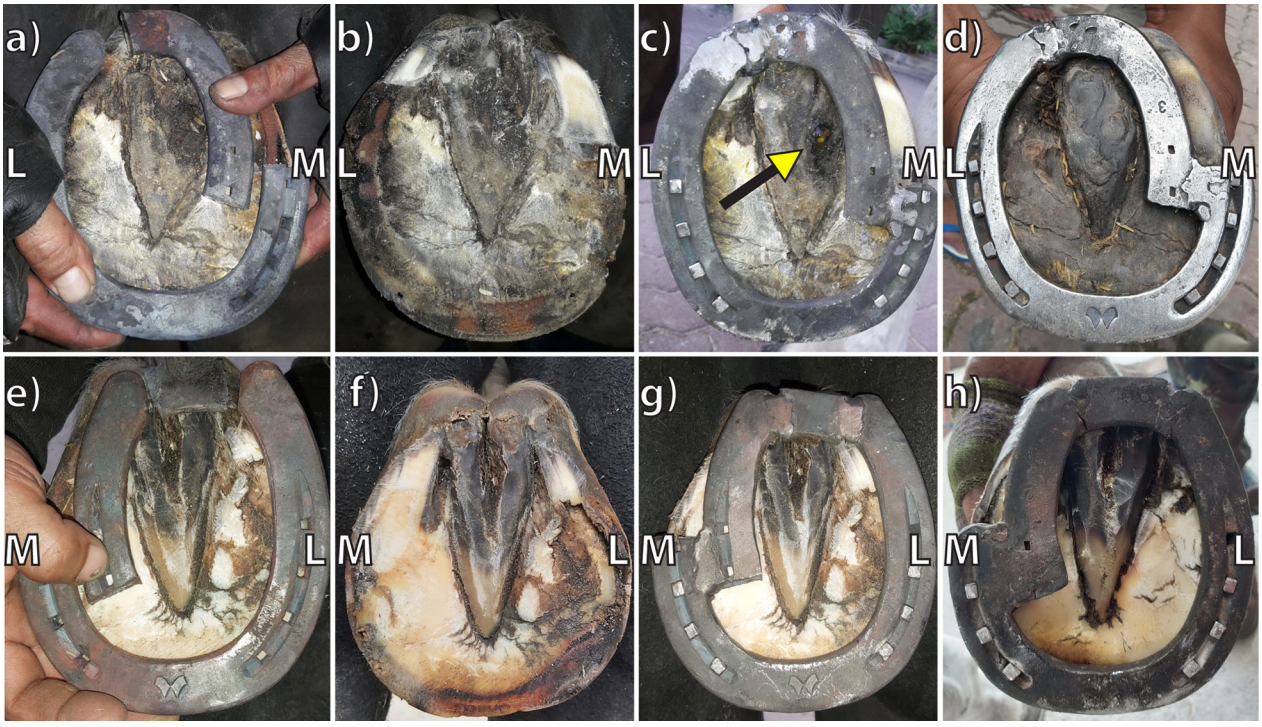

Fig. 3. Modified Z-bar shoe and application of it to the injured hooves. The upper and lower rows illustrate the creation of the modified Z-bar shoes and application of them to the left forelimb of horse 1 and the right forelimb of horse 2, respectively. Custom metal shoes were created to avoid the frog bruise areas (a and e). The affected feet were trimmed explicitly at the heel region, particularly at the medial palmar areas (b and f). The shoe was welded together and put on the affected hooves (c and g). The frog bruising disappeared within four weeks after shoeing (d and h). The fresh wound (yellow arrowhead) accompanying frog bruising in horse 1 healed by four weeks after shoeing (d). L, lateral side; M, medial side.

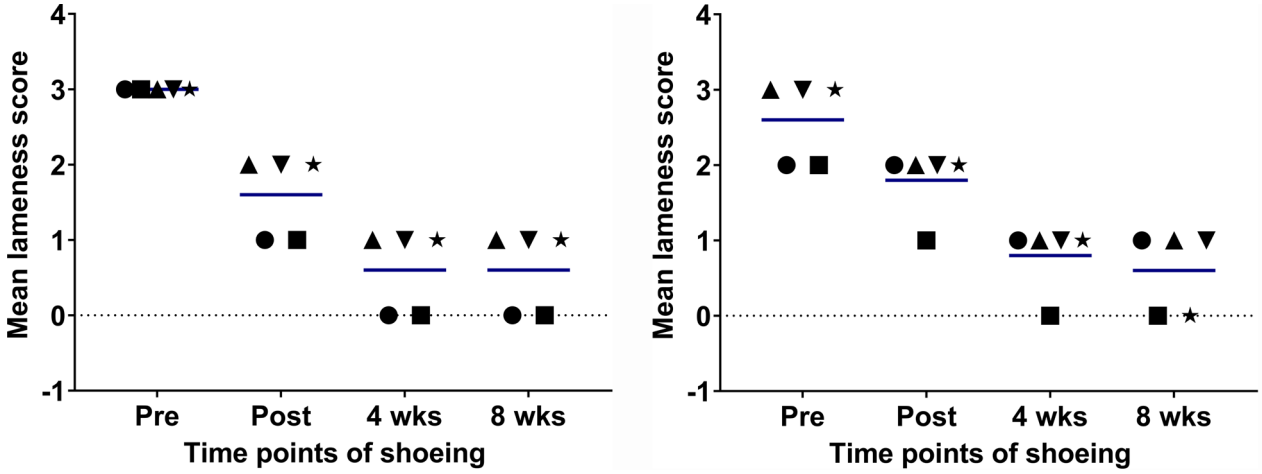

Fig. 4. Lameness scores of each horse as evaluated by five persons (●, ■, ▲, ▼, ★) before shoeing (Pre), immediately after shoeing (Post), four weeks after shoeing (4 wks), and eight weeks after shoeing (8 wks) with the modified Z-bar shoe in horse 1 (upper image) and horse 2 (lower image).

shoeing, causing recurrent lameness. It is plausible that the Z-bar shoe's central bar presses against the frog region more often than usual and consequently injures the frog area.

Modified Z-bar shoes were made to avoid compression of the affected frog region, following the basic principle of mechanical stress elimination [2, 3]. Specific trimming might also be required before shoeing because underrun heels could result in navicular syndrome [6, 19, 20]. Thus, the collapsed heels of both horses were trimmed as thin as possible to create space between their heels and the modified bar shoe, resulting in the removal of weight-bearing stress on the heel regions. This procedure could help eliminate pain and promote the growth of the affected heels.

As expected, the frog bruising disappeared after shoeing with the modified Z-bar shoe, and the horses showed almost no lameness four to eight weeks after shoeing. The horses were continuously shoed with the modified Z-bar shoe and started training eight weeks after the modified Z-bar shoeing. However, minor gait irregularities were observed occasionally in both horses after the study period. Since both of these ageing horses have continued to participate in equestrian events in the decade before their retirement, an undetected degenerative disease may persist in their musculoskeletal structures, and it may be contributing to the slight gait abnormality. The small number of assessed horses is a limitation of this case report. Validation of the modified Z-bar shoeing method with a more significant number of horses is necessary. Nevertheless, the modified Z-bar shoe may be an alternative shoeing method for horses diagnosed with navicular syndrome resulting from underrun heels.

In conclusion, a modified Z-bar shoe can eliminate occasional complications accompanying the previous style of Z-bar shoe. In addition, retention of the specific shoeing characteristics for the underrun heel and navicular syndrome would be required to manage this modified Z-bar shoeing appropriately. Collaboration between the farrier and veterinarian is required to improve this aspect of horse health.

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