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Clinical Report

Treatment of Hoof Disease in an Asian Elephant (*Elephas maximus*) Using Creative Surgery: A Successful Case Report

Guanghao Lin[1], Liming Chen[2], Youfeng Xu[3], Peng Wei[1*]

[1] *Plastic Repair Reconstructive Surgery Department, Ningbo First Hospital, Ningbo, China.*

[2] *Animal Management Department, Ningbo Youngor Zoo, Ningbo, China.*

[3] *Department of Ultrasound, Ningbo First Hospital, Ningbo, China.*

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Abstract

Case Description- Chronic foot disease, which is considered a tremendous clinical challenge, poses a serious threat to the overall health of elephants. We treated an Asian elephant with hoof disease by a creative surgery.

Clinical Findings- An Asian elephant presented with hoof disease, which caused the partial detachment of its right hind foot-pad.

Treatment and Outcome- We fixed the elephant's foot by using an artificial steel plate and sternal wire, At the same time we adjusted diet. Elephant hoof disease is cured and its function restored.

Clinical Relevance- The utilization of fixation plates can be extremely useful for the treatment of hoof disease in the elephant.

* Correspondence to: Peng Wei; Plastic repair reconstructive surgery Department, Ningbo First Hospital, Ningbo, China. E-mail: dr_weipeng@163.com

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1. Introduction

Elephants are first-class protected animals in China. They are also among the largest terrestrial mammals. Unfortunately, elephants that are well fed in zoos worldwide often die under abnormal circumstances for various reasons.[1] The death of elephants usually results in considerable economic losses to China. The limbs, especially the hooves, which support the body weight of such large animals are prone to various diseases. Chronic foot disease, which is considered a tremendous clinical challenge, poses a serious threat to the overall health of elephants and is often an important reason for euthanizing large herbivores in captivity.[2] In July 2017, an Asian elephant at the Younger Zoo in Ningbo, China, presented with hoof disease, which caused the partial detachment of its right hind foot-pad. After surgical correction, the elephant showed favorable recovery, which is detailed in the following report.

2. Case Description and Clinical Findings

In July 2017, a 25-year-old female Asian elephant (*Elephas maximus*) weighing 3000 kg, housed at the Ningbo Younger Zoo, was found with a crack in the bottom of the right hind foot, the crack was 2 cm long and 1 cm deep in the medial edge. Soft tissue was visible within the wound, and the erosion of the surrounding tissues and development of scar tissue were evident. Although the wound was flushed daily with 10% povidone-iodine and normal saline, its length and depth still increased with rapid progression. On July 27, the length of the crack reached 7 cm. We then flushed the wound with povidone iodine and hydrogen peroxide twice daily. In addition, the wound was soaked in 0.1% potassium permanganate solution, and the necrotic tissue was trimmed. The animal's level of activity was also reduced to slow down the process of further opening of the wound. On August 10, the wound was observed to be inwardly curved, its length was increased to 15 cm, and depth was about 5 cm. The upper part of the wound comprised immature scar tissue, which was separated from the sole of the foot. The gait of the elephant was affected by the diseased hoof.

When swabs of the deep tissue of the cleft of the wound were cultured, the results were not suggestive of a bacterial infection. During the period of initial treatment, several blood tests and serum biochemical tests were also conducted. No significant abnormalities were evident when the values of the patient were compared to those measured in other healthy Asian elephants in our facility and other zoos.

Before July 2017, the demeanor, appetite, and body temperature of the elephant was normal. In addition, its gait during daily activities was unremarkable, and the excretion of urine and elimination of feces were consistent and regular. However, at the beginning of July, the level of activity was reduced and the elephant spent more time in recumbency. In addition, its gait was indicative of mild lameness. Its appetite and urine showed no significant changes, and its demeanor was favorable. On August 15, the gait was indicative of slight lameness, and the duration of contact between the right hind foot and the ground was reduced. When standing, the elephant consistently rose against a wall, and its level of activity was further reduced.

3. Treatment and Outcome

During initial treatment from July 1 to July 26, the wound was subjected to daily alternating irrigation with iodine and physiological saline; however, the length of the wound increased from 2 cm to 7 cm. From July 27 to August 10, the wound was washed with 0.1% potassium permanganate solution, iodine, and physiological saline. The bottom of the hoof was carefully trimmed daily. The level of activity was progressively reduced and the wound continued to expand rapidly.

During the second treatment protocol from August 10 to August 29, the length of the wound reached 15 cm. On assessing the wound, we used ultrasound to probe the foot

and found no obvious abscess cavity and observed a small amount of hyperplastic tissue above the wound that could have been externally fixed, without the need for anesthesia. We designed a special structure for fixation and determined the site of fixation. On August 11, we prepared the animal for a plate fixation procedure. After a thorough preoperative assessment, since the surgery does not involve soft tissue and there was no obvious pain, we used ketamine (0.1 mg/kg) by intramuscular injection to sedate, flex its knee on the right hind leg by 90 degrees, and place it to rest on an iron frame. We also fed the elephant as a means of distraction.

We used 50 ml povidone iodine to flush the wound under pressure. During the operation, we observed that the length of the plantar cleft was about 12 cm and the depth was about 5 cm (Figure 1). The tissue being shed was very loose, and fusiform tissue measuring about 1 × 6 cm was observed at the proximal hoof (Figure 1). We then placed an eight-hole orthopedic reconstruction plate at the distal extremity and a six-hole orthopedic reconstruction plate at the proximal phalanx. The center of the two plates were aligned and both plates were placed in a position that was parallel to the sole of the hoof. 1.0 mm sternal wire with needle was used for fixation of the plate. The six-hole plate was externally sutured at holes 1, 2, 3, 4, 6, and 7 of the eight-hole plate (Figure 2), and the sutures were then tightened. The operation went well and lasted 18 min. As any prolonged procedure with the right foot in a flexed position would have led to discomfort of the elephant, we placed the foot flat on the ground for about 8 min. On August 29, tissue organization was evident above the wound, and the thinnest part of the tissue was about 2 cm wide. We removed the plate, resected some of the shedding heel and trimmed the edge. The activity level of the elephant improved considerably and its gait returned to normal.

During the third treatment protocol, the hoof showed an imbalance, due to partial removal of the foot-pad (Figure 3). We trimmed the foot-pad daily, as when performed appropriately, this practice can restore balance to the plantar surface. On October 6, the sole was examined (Figure 4) and its thickness was about 3 cm. The gait was normal, and the level of activity returned to normalcy.

Figure 1. On August 15, the length of the crack at the base of the right hind foot increased to 12 cm, with inward curvature, and a depth of about 5 cm.

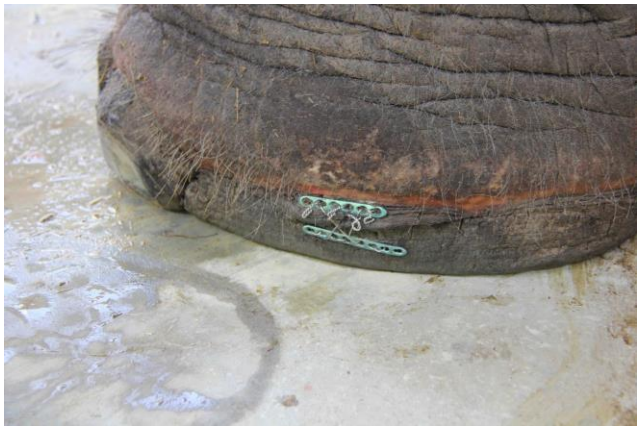

Figure 2. Plate fixation on the right hind foot in a standing position.

4. Clinical Relevance

Under the conditions of artificial breeding in a zoo, hoof disease in the Asian elephant can be very common. The main reasons for this include: (1) The hooves may remain in manure and urine for relatively long periods. The wet, dirty environment can soften the foot-pad, and thereby lead to infections if nails and foreign objects become embedded in the pads. (2) In a captive environment, elephants are more prone to behave abnormally. Repetitive or stereotypic behaviors can also cause hoof problems.[3-5] (3) Differences in the place of birth or origin and diet, in addition to improper nutrition results can lead to imbalances in

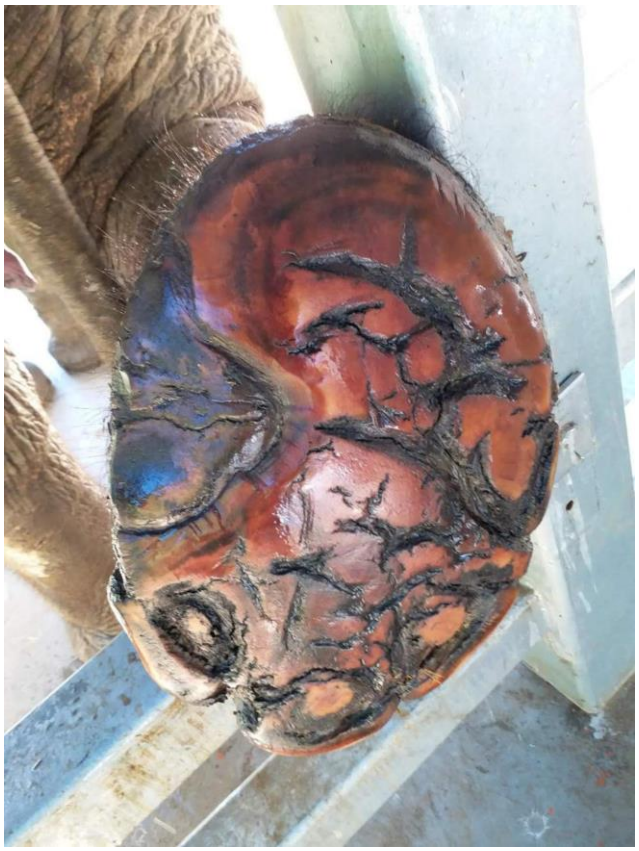

Figure 3. On August 29, the repaired hoof after the plate was removed.

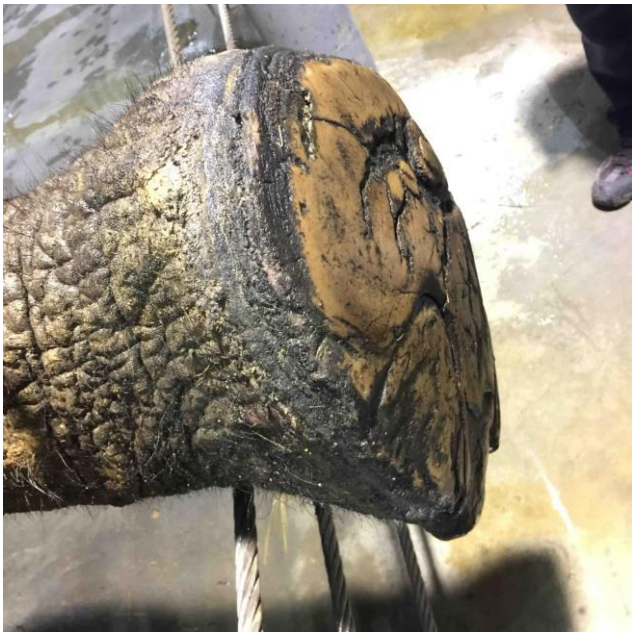

Figure 4. Follow-up at 2 months showed satisfactory results, with improved functional restoration and activity level.

phosphorus and calcium. This in turn can lead to loosening of the horny tissue of the hoof.[6] Other reasons that can cause hoof disease include: (1) The natural shape of the leg, as the elephant may walk with an abnormal gait, thus exerting excessive pressure on only one side of the hoof. This action would increase the wear on the foot and can possibly lead to hoof cracks. (2) When one leg is injured, it can become very stiff. An injured leg can thus also lead to abnormal wear of the sole.

The innovative use of titanium steel plates and stainless steel wire in the surgical repair of abnormal hooves is feasible, owing to the following considerations: (1) The traditional methods of reducing the activity level of elephants and washing the hooves with disinfectants do not effectively retard the process of shedding. If rocks and other objects get into hoof cracks or wounds, the injury to the sole can become more critical. (2) The body of the Asian elephant is extremely huge. After repair of the hooves, the joints need to withstand extremely high levels of stress during standing and walking. Steel plates are characterized by high strength and resistance to fatigue, and a very small steel locking plate can accommodate several holes. Furthermore, stainless steel wire can aid in distributing the stress on the joints more evenly. The use of steel wires designed for humans is feasible, if conditions permit. (3) After fixation, a small titanium alloy plate and stainless steel wire can facilitate daily observation and care for the affected area. (4) The hooves may be exposed for relatively long durations within the feeding environment, where feces and urine can accumulate. Thus, the effects of the disinfectant are not preserved during the course of treatment, and the connecting materials may easily become susceptible to damage. The materials described above have favorable resistance to corrosion, and can remain in place for an extended duration, without structural damage. (5) Exposed tissue of the phalanx is very weak, and the skin can be easily damaged and become infected if it is subjected to repeated friction with the connecting material. Steel is not prone to corrosion and can retain a smooth surface; thus, it has favorable biocompatibility and adverse reactions within the tissue are rare. (6) The traditional treatment for hoof disease and abscesses entails covering

the affected foot with a cap. However, whether the foot cap is hollow or closed, several potential problems may be associated with treatment. The foot cap has to be removed each time treatment is administered, so that the hoof can be adequately trimmed. In addition, urine and feces can easily accumulate within the foot cap, and this accelerate the process of splitting in the hoof. (7) The operation also has its limitations. As the foot-pad had been partially shed, the use of a steel plate was only feasible when the proximal end of the hoof had regenerated a small amount of tissue. If the wound happens to be at the junction between the foot and the sole, surgical fixation cannot be performed. Considering these circumstances, we carefully treated the elephant until tissue regeneration and organization was sufficient to permit surgery. (8) Inaccurate prediction of the extent of repair required for the first surgical procedure will result in poor fixation. Therefore, the length of the steel plate should be similar to, or longer than the length of the wound to ensure sound fixation. (9) The materials used for the surgery described above were all designed for use in humans, and the cost was also relatively high. However, use of the surgical method adopted was still very valuable. The potential susceptibility of elephants to hoof disease is extremely high. Adoption of the surgical method and materials detailed in the present report ensures firm fixation of the sole, and retards the process of cracking. This can facilitate the normal proliferation of the plantar surface of the foot and prevent further deterioration of any cracks or wounds.

In summary, prevention is crucial to hoof disease in the elephant.[4] Some important considerations include the following: (1) The feeding environment of elephants should be improved and enclosures should be kept dry, especially when hoof disease is evident. The ground should be slightly sloped to facilitate the timely drainage of urine and other fluids. Layers of hay and sand on the ground as a bed may also help. (2) Greater attention should be given to the foot of the elephant, which should be checked everyday. Timely repairs should be performed when symptoms first become evident, rather than drastic trimming on sporadic occasions. (3) The formula of the feed and level of nutrition should be adjusted, to increasing the intake of appropriate vitamins. Such adjustments, can both accelerate the proliferation of hoof tissue, and improve the hardness, compressibility, and compressive strength of the foot-pad. This report shows that the utilization of fixation plates can be extremely useful for the treatment of hoof crack disease in the elephant.

Declaration of interest

The author does not have any conflict of interest.

Acknowledgments

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