



NOTE

Wildlife Science

Novel treatment for chronic pododermatitis in an Indian elephant (*Elephas maximus indicus*) with Mohs' paste

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ABSTRACT. Asian and African elephants are frequently afflicted by foot disorders that can be very challenging to manage even with aggressive therapy. Such conditions may have indirect life-threatening effects. Mohs' paste (zinc chloride based escharotic agent) was used to treat a female Indian elephant (*Elephas maximus indicus*) aged 39 years with foot disorder at Kanazawa Zoological Gardens. Degenerated hyperplastic tissue was observed inside the hoofs of digits 2 and 5. Mohs' paste was applied on the lesions, which coagulated the hyperplastic tissue and restrained its proliferation. Subsequently, the hyperplastic tissue could be trimmed with little pain, and the disorder became manageable. Mohs' paste treatment was effective and is expected to be an alternative treatment for hoof disorder.

KEY WORDS: *Elephas maximus indicus*, haemostasis, hoof trimming, Mohs' paste, tissue coagulation

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A female Indian elephant (*Elephas maximus indicus*) (aged at 39 years in 2017; weighing 3,800 kg) housed at Kanazawa Zoological Gardens, and has been maintained since 1985. The elephant was born in wild and brought from Mumbai, India. The indoor and outdoor enclosures of the elephants are covered with concreted ground. The elephant is managed directly through contact and can be routinely treated. The elephant, at 31 years of age, had several cracks on her hoof sole, occasionally extended to the hoof wall, especially on digits 2 and 5 on the left forelimb. Copper naphthenate (concentration as Cu: 4.7–5.3%; Junsei Chemical Co., Ltd., Tokyo, Japan) was applied to the trimmed hoof. This treatment was repeated until the cracks were covered by the new hoof tissue.

When the elephant was 38 years old, a sole ulcer was found on digit 2 of the left forelimb. The elephant did not cooperate during treatment because of the pain. Although the lesion had been treated with five months of copper naphthenate application, the trimmed hoof had always remained haemorrhagic and the degenerated hoof tissue became hyperplastic (approximately 5.0 cm in diameter; Fig. 1a). Therefore, an alternative treatment was considered. Mohs' paste that is a zinc chloride based escharotic agent was prepared from a mixture as Table 1. The modified Mohs' paste for the elephant was prepared in the present study. Mohs' paste was applied to the lesion in the sole ulcer (Fig. 1b), and a foot soak with liquid iodine was also initiated. The paste was initially applied on the lesion for only 10 min under the keeper's observation during which the elephant was in the standing position. Next day, hyperplasia of degenerated hoof tissue was no longer observed, and the tissue surface became necrotic. This necrotic tissue was trimmed (about 2–5-mm thick) until the vascularizing tissue was exposed; afterward, the paste was applied to the lesion and haemostasis was observed because of the paste. The hoof was trimmed using different types of well-sharpened hoof knives and rasps, as was described in a previous study [2, 3, 19]. In addition, a rapid spray-type freezing mixture (EM freezer, Nisshin-em Co., Tokyo, Japan) was sprayed on the lesion and the lesion was frozen within a few second when the hyperplastic tissue was trimmed. An ultrasonic cutter (SUW-30CMH, SUZUKI Motor Co., Shizuoka, Japan) was used to trim the hard hoof and the

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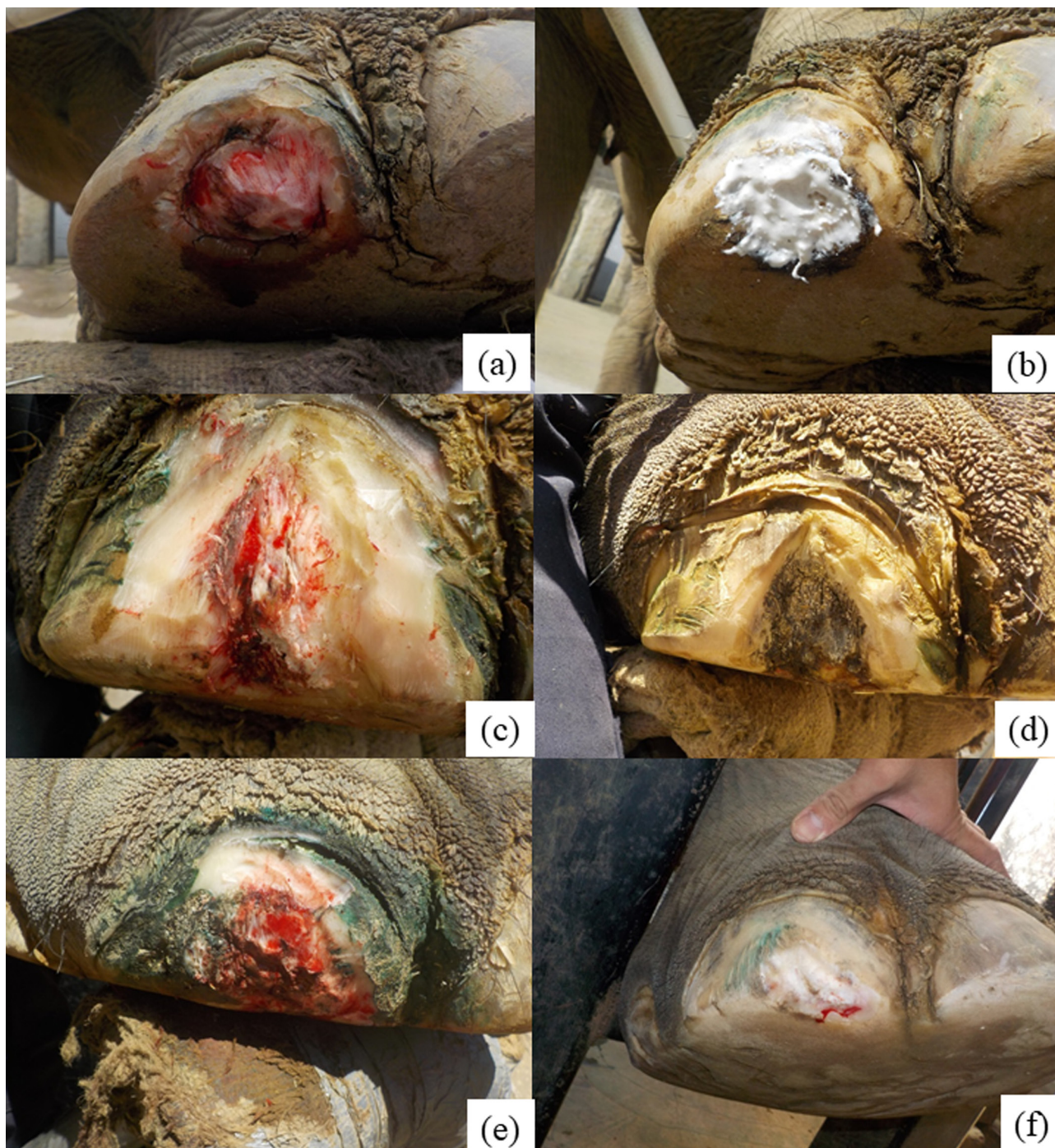


Fig. 1. Changes in digit 2 of the left forelimb in an Indian elephant (*Elephas maximus indicus*) affected by hoof disorder. (a) 1 month before the start of Mohs' paste application. A large sole ulcer in the hoof sole that was bleeding and was painful for the elephant. (b) Day 3, when Mohs' paste was applied on the hoof ulcer lesion. (c) Day 137, when the wide area inside the hoof wall was infiltrated by the hyperplastic tissue. (d) Day 145, when Mohs' paste was applied on the hoof wall lesion. (e) Day 230, when Mohs' paste was applied on the surface of the hyperplastic tissue and the surface was trimmed little by little. (f) Day 305, when the hyperplastic tissue was no longer observed and the hoof shape had almost recovered.

hyperplastic tissue. The large black necrotic tissue remained prominent at the centre of the lesion. Therefore, paste application to the lesion was stopped on day 34. Afterward, the hyperplastic tissue vigorously proliferated from the peripheral lesion. On the 98th day, a fistula inside the hoof wall was detected from the hoof sole to the coronet by contrast radiography. Subsequently, the hoof wall was trimmed, and the degenerated hoof tissue was eventually detected inside the hoof wall. The application of the paste was resumed on day 137, and the wide area of the hoof wall was trimmed (Fig. 1c). The hyperplastic tissue was covered with scabs after applying the paste (Fig. 1d). On day 181, the centre of the lesion was covered with black necrotic tissue, and the

Table 1. Formulation of the modified Mohs' paste in the present study

Materials	Mohs (1941) [15]	Kakimoto <i>et al.</i> (2010) [10]	Fukuyama <i>et al.</i> (2016) [4]	Modified Mohs' paste 1.25 times ^{a)}
Saturated zinc chloride (ml)	34.5			
Zinc chloride (g)		60	5	3.1
Purified water (ml)		30	2.5	1.2
Stibnite (g)	40			
Powdered <i>Sanguinaria canadensis</i> (g)	10			
Zinc oxide starch powder (g)		30	2.5	1.4
Glycerin (ml)		15	1	

a) The zinc content of the modified Mohs' pastes was 1.25 times greater than the original Mohs' paste.

hyperplastic tissue proliferated around this necrotic tissue. Histopathological examination (Kagoshima University, Kagoshima, Japan) of the hyperplastic tissue revealed suppurative dermatitis with hyperkeratinization and bacterial colonies. The hyperplastic tissue proliferated from the peripheral lesion. Mohs' paste was applied to the hyperplastic tissue, and this hyperplastic tissue was trimmed little by little (Fig. 1e). Because the elephant did not touch the Mohs' paste after application, the paste was retained on the lesion for four hr since day 209. Since day 249, the proliferation of hyperplastic tissue declined, and the lesion was slowly covered with normal hoof tissue from the peripheral lesion. Day 273 was the last day of Mohs' paste application. The lesion was covered by normal hoof tissue. The hoof shape had almost completely recovered on day 306 (Fig. 1f).

During the first day, the hoof coronet by the 5th digit on the left forelimb was swollen, and the elephant exhibited a strong pain reaction. Afterward, the hoof wall around the swollen hoof coronet was trimmed, and degenerated tissue was identified inside the hoof. Further, after trimming, the lesion was noted to have reached the hoof sole, affecting a wide area of it. Mohs' paste was applied to this lesion from day 10 onward; the necrotic tissue was trimmed and the hoof wall was widened (Fig. 2a). Mohs' paste was applied the hyperplastic tissue. On day 47, most of the hyperplastic lesions were trimmed (Fig. 2b), and Mohs' paste application was stopped. The proliferation of hyperplastic tissue declined and the tissue was not haemorrhagic. The center of the lesion was occupied by the degenerated tissue and the hoof wall slowly grew on day 128 (Fig. 2c). On day 160, the grown hoof wall was trimmed little by little and the degenerated tissue in the center was gradually harden (Fig. 2d). The hardened degenerated tissue was trimmed on day 225 and the normal hoof tissue was found (Fig. 2e). The hoof shape had almost completely recovered on day 292 (Fig. 2f).

The elephant foot has evolved to bear heavy weight by developing a highly compliant fibrous-fatty pad in the foot area [22]. Although people are vigilant in trying to keep the elephant foot healthy, many captive elephants develop foot disorders [2, 3]. A retrospective study revealed that 50% of all captive elephants or 80.4% of the elephants kept in enclosures with unnatural or hard surfaces were affected by foot-related disorders [6, 13]. In addition, Miller *et al.* [14] reported that 145 of 215 elephants that underwent physical examinations had foot problems, and 92.4% showed hoof abnormalities such as inflammation, cracks, abuses, defects, and horn growth. Significant complications such as osteomyelitis could occasionally develop from abscesses [5, 7]. Therefore, intensive treatment should be initiated, such as daily debridement, foot soaks, and parenteral antibiotic therapy [2, 3, 8]. In addition, administration of topical antimicrobial agents such as copper sulfate, 10% formalin, and copper naphthenate is recommended [3]. However, despite these aggressive treatments, foot disease in elephants is known to be very challenging to manage [17, 18].

The degenerated hyperplastic tissue commonly observed in hoof disorder may prevent successful treatment, because the tissue is fragile, bleeds easily, and is very painful. Invasive surgery will occasionally be necessary under anesthesia along with long and intensive postoperative care. Further, specific instruments and well-trained and experienced personnel will be necessary [2, 9].

An alternative treatment that does not require anesthesia might be useful to treat captive elephants, particularly in settings without specialised instruments and experienced medical personnel. Our study revealed that Mohs' paste was effective for the treatment of hyperplastic hoof disorders in elephants. Mohs' paste could chemically coagulate the tissue and prevent the proliferation of hyperplastic tissue. Mohs' paste is known as zinc chloride fixative paste. Zinc is ionised by exudate from the lesion, and the protein is coagulated by the astringent effect of ionised zinc [1, 15, 16, 21]. Therefore, this zinc fixation method might be useful in preventing degenerated tissue proliferation. Haemostasis was also observed in the lesion after trimming. Various studies have reported that Mohs' paste has haemostatic effects on malignant wounds [4, 10, 12]. Although in the present study severe haemorrhage was frequently observed on the trimmed lesion, the haemostatic effect of Mohs' paste was present. Mohs' paste coagulated the hyperplastic tissue and allowed trimming without causing severe pain to the elephant.

There are no existing rules regarding the contact time and frequency of use of Mohs' paste in treating elephant hoof disorder. Shigeyama *et al.* [20] described that 5- and 10-mm-deep tumour tissues were fixed after 48 and 72 hr, respectively, after application of 1-mm-thick Mohs' paste. In addition, the haemostatic effect was observed after 10 min of contact with Mohs' paste [10]. In veterinary medicine, there is the risk that the animals may accidentally ingest the paste. This, therefore, requires the animals to be under controlled conditions during the application of Mohs' paste. In the present study, the elephant had to be under the keeper's observation during the application of Mohs' paste because the elephant could easily touch the paste using its trunk. Therefore, initially, Mohs' paste was only allowed to remain on the lesion for 10 min daily, and later increased to four hr daily after we



Fig. 2. Changes in digit 5 of the left forelimb in an Indian elephant (*Elephas maximus indicus*) with hoof disorder. (a) Day 16, when the hyperplastic tissue was observed inside of the hoof wall. (b) Day 47, when the hyperplastic tissue was almost completely trimmed and the conceivable dermis was identified just behind the trimmed tissue. (c) Day 128, when the center was occupied by the degenerated tissue. (d) Day 160, when the degenerated tissue in the center was gradually hardened. (e) Day 225, when the normal hoof tissue was found after trimming. (f) Day 292, when the hoof shape had almost recovered.

recognised that the elephant did not touch the paste. Because Mohs' paste had to affect the lesion during the limited application time, the zinc content of the modified Mohs' pastes was 1.25 times greater than the original Mohs' paste. Consequently, Mohs' paste was contributed to gradually heal the wound.

Mohs' paste also affects normal tissue [4]. Although the Mohs' paste addressed the lesion, scorched necrotic tissue was observed at the centre of the lesion in the second digit, around day 180. At that time, there was a concern that the Mohs' paste may affect the dermis. Therefore, much attention should be paid to the difference between the normal dermis and the hyperplastic tissue in the

hoof. One of the major differentiating factors is consistency. The hyperplastic tissue was very soft and fragile, whereas the normal dermis was tough and elastic.

The lesion on digit 5 could be trimmed rapidly than on digit 2. This difference may be caused of the following: the hoof wall and sole were widely opened on digit 5 at the first treatment stage and Mohs' paste could be applied to the whole of the lesion. Therefore, the early trimming of the hoof wall and sole may be recommended.

Hoof infection has been observed to be common in captive and wild elephants [11, 13, 17]. Although a few reports have described the etiology of hoof infection, a previous study showed that abnormal pressure on the hoof might induce a bruise inside the hoof and cause sterile and abnormal tissue formation [19]. Subsequently, this tissue might spread inside the hoof and get infected via cracks in the hoof sole or ruptures in the cuticle. In our case, the hoof was infected, and histopathological examination of the hyperplastic tissue revealed suppurative dermatitis. Cracks had always been found in the hoof sole and the inside of the hoof wall. Although these cracks were trimmed and opened to prevent infection, one of the cracks might have been a route for bacterial infection in the hoof. Hoof disorders including laminitis and sole ulcers are also common in cattle and horses. The etiology and treatment of these diseases in cattle and horses are established, but those in the elephant should be further studied. The difference between these domestic animals and the elephant is the size of the lesion and the mode of treatment. Elephant cooperation for treatment is essential. Even if the elephant cooperates for treatment, the lesion cannot be normally covered with bandages or protected from dirt in the surrounding environment. Although hoof rubber shoes were recommended in previous studies [2], introducing such shoes might be difficult in most zoos. Therefore, specific treatment should be considered for elephant hoof disorder, and Mohs' paste might be one of the effective solutions.

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