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Research Article
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Incidence of Abnormality in Spinous Processes of the Thoracic Vertebrae in Abused Asian Elephants with Radiographic Evidence

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Abstract. This study investigates the effects of saddle use on Asian elephants in captivity, focusing on issues like saddle gall and spinal damage caused by factors such as inadequate cushioning and overloading. Radiographic evidence from cases involving Asian elephants illustrates varying degrees of dorsal spinous process degeneration, impacting gait and body structure. The findings underscore the need for clinicians to use radiography in evaluating elephant skeletal health and advocate for improved health monitoring practices among elephant caretakers.

Introduction

At least in range countries, Asian elephants (*Elephas maximus*) in human care are used for carrying out many activities such as patrolling, koonkie, timber hauling, fodder collection, safari rides, joyrides for tourists, and participating in religious and civil ceremonies. Maintaining elephants purely for work may compromise the welfare conditions of the animals and hinder the species-specific activity of their choosing (Varmal *et al*. 2010).

It is paramount to ensure proper fixation of the saddle (howdah) on elephants that are carrying persons on their back. An improperly fixed saddle or overloading may result in saddle gall formation and induce inflammatory changes at the edges of the dorsal spinous processes due to chronic friction between the saddle and the dorsal spine (Bansiddhi *et al*. 2019). In Thailand, potential interventions suggest risk factors associated with skin of elephants that are used in the tourism industry due to saddle (Magda *et al*. 2015).

Elephants that are suffering from saddle gall, which later become a huge, infected wound on the dorsal spine and takes several months to heal completely. While healing, fibrotic scar tissue and callus are formed on the dorsal spinous processes which adheres together leading to complete or partial fusion of the dorsal spinous processes in the meaning of an ankylosis. In addition, the process may lead to various degrees of degenerative changes due to damage in growth plates. This results in abnormal body conformation and gait alteration of the elephant. Changes in gait patterns, effects on musculoskeletal function, and joint kinematics may be attributed to the impact of weight carriage on Asian elephants used for riding (Kongsawasdi *et al*. 2021). In equines, the "kissing" spinous processes of the lumbar vertebrae is considered one of the reasons for back pain (Turner 2003; Jeffcott & Haussler 2004).

In elephants, radiography is particularly helpful for the detection of chronic changes in bones or joints (George 1989; Gage 1999). Growth plate closure was defined as the time at which a radiolucent physis was no longer visible radiographically (Siffert 1981). Information about the growth plates of the spinous processes (latin: *Processus spinosus*) of the thoracic vertebrae of Asian elephants is largely unknown. Consequently, the objectives of this study were to determine the nature of lesions on the spinous processes in Asian elephants possibly caused by carrying heavy objects on its back, compromised welfare and management through radiographic evidence. The authors also demonstrate

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Figure 1. Photographs showing severely abused and exploited elephants.

differences in the growth plate closure of these dorsal spines in comparison to thoracic radiographs of apparently healthy individuals.

Methodology

Wildlife SOS, an NGO, established an Elephant Conservation and Care Center in India to provide proper veterinary care and nutrition to elephants rescued from abusive and challenging conditions (Fig. 1) in human care. The facility features an on-site hospital equipped with a wide range of therapeutic as well as diagnostic capabilities.

The elephants underwent positive reinforcement training to facilitate their comfort with sitting in an elephant restraint device (ERD) and familiarity with the radiographic examination procedure. Radiographs were taken using a portable direct digital radiography unit (EPCORSA 2.4, Epsilon Healthcare Solutions Pvt. Ltd.) with a Focus 35C detector (14×17 inch, Carestream, India). The X-ray generator and imaging plate were positioned bilaterally alongside the spine, with the imaging plate oriented perpendicular to the primary X-ray beam. (Fig. 2). Serial lateral radiographic projections were obtained using standardised exposure settings of 70 kV, 38 mA and 30 mAs to evaluate the elephants' skeletal health systematically.

Figure 2. Illustration of X-ray imaging.

The body condition scoring of elephants was assessed using visual observations based on criteria described by Wijeyamohan *et al*. (2014).

Results

Case 1

Inspection: Female, 29 years, BCS 1/10, alteration in conformation, altered gait, severe scars and depression in the dorsal aspect of the body.

Radiographic findings: Degenerative changes were observed in the thoracic vertebrae (T) 13-15 (Fig. 3b & 3c; marked with red arrow), while abnormal fusion of the spinous processes T16–T18 (Fig. 3a; marked with yellow arrows) and adhesion of the spinous process to the skin were noted at T19.

Case 2

Inspection: Male, 20 years, BCS 2/10, no visible scar on the skin but an abnormal projection on the dorsal spine was encountered.

Radiographic findings: Severe degenerative changes were observed in the dorsal spinous processes, along with avulsion of the growth plate avulsion from the spinous processes. Fusion of two thoracic spinous processes was noticed accompanied by severe degenerative lesions at T14–T15 (Fig. 4a; marked with yellow circle). Fragmentation of growth plate was also observed in several spinous processes, specifically T15–T19 (Fig. 4b; marked with white arrows). The epiphyseal growth plates are still visible (Fig. 4a; marked with red arrows).

Case 3

Inspection: Male, 57 years, BCS 1/10, presented with a history of chronic septic wounds due to saddle gall.

Radiographic findings: Severe degenerative changes were observed on spinous processes from T14–T19 (Fig. 5b & 5c; marked with red arrows) along with a kissing spine phenomenon between T18 and lumbar vertebrae 1 (L1) (Fig. 5a; marked with yellow arrow).

Figure 3. Abnormal fusion of spinous processes.

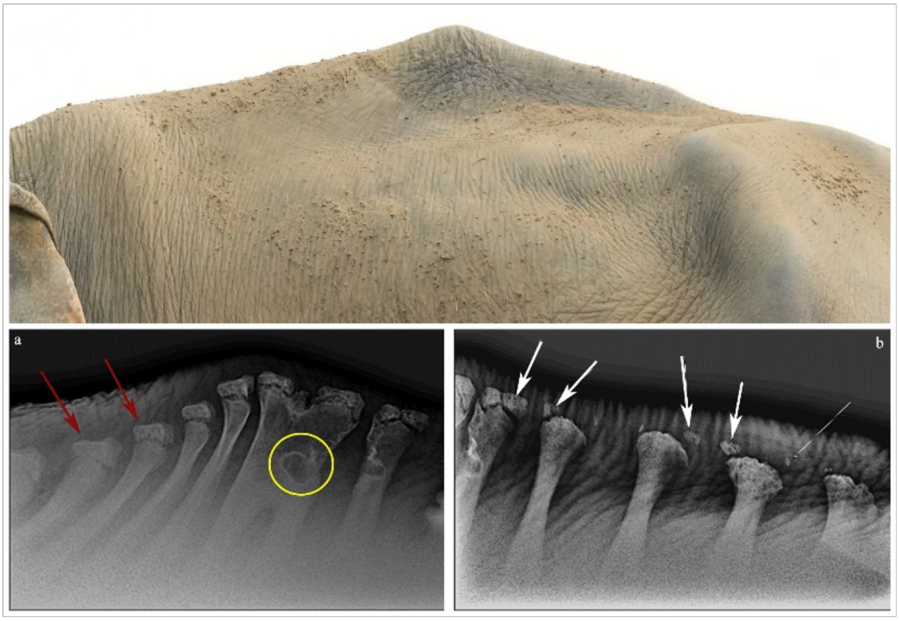

Figure 4. Growth plate fragmentation and avulsion from the spinous processes.

Figure 5. Spinous processes of thoracic vertebrae showing severe degenerative changes.

Case 4

Inspection: Female, 25 years, BCS 3/10, Abnormal swelling with ulceration of skin on the dorsal aspect of the body (marked with red arrow) was noticed.

Radiographic findings: Mild degenerative changes were noticed in the spinous processes, along with excessive thickening of the skin and no signs of abscess lesion/skin adhesion were noticed. The epiphyseal growth plates were not clearly visible indicating the initiation of epiphyseal mineralisation in the T16–T19 (Fig. 6a & 6b; marked with yellow arrows).

Case 5

Inspection: Female, 21 years, BCS 1/10, presented with degenerative joint disorder affecting forelimbs. Locomotion of the elephant is being affected due to abnormal gait.

Radiographic findings: Mild degenerative changes noticed in the spinous processes and fibrotic adhesion (Fig. 7a; marked with yellow arrows) was noticed at T12 and T13, possibly attributed to consistent saddle compression and overloading.

Case 6

Inspection: Female, 51 years, BCS 3/10, abnormal projection of dorsal spine encountered.

Radiographic findings: Various degrees of degenerative changes and remodelling of the dorsal spinous processes were observed from T14–T18. Abnormal callus formation was noticed at T16–T17, potentially indicative of fu-

Figure 6. Radiograph of thoracic spine showing mild degenerative changes in the spinous processes.

ture fusion (Fig. 8a; marked with yellow arrow). Furthermore, T9–T13 exhibited an unusual curvature at the tip with degenerative changes, likely due to partial avulsion of the growth plate caused by constant saddle pressure cranially with over loading (Fig. 8b; red arrows).

Case 7

Inspection: Female, 29 years, BCS 2/10, severe arthritis with abnormal gait. Elephant is exhibiting symptoms of lameness and degenerative joint disorder with both hindlimbs.

Radiographic findings: Degenerative and osteolytic changes were noticed on the dorsal spinous processes from T5–T7 and T12–T15 (Fig. 9a & 9c; marked with yellow arrows).

Case 8

Inspection: Male, 50 years, BCS 2/10.

Radiographic findings: Fragmented radiopaque lesions were observed between T4 and T5 of the spinous processes (Fig. 10a; marked with yellow arrow) suggesting potential growth plate avulsions and degenerative lesions. Kissing spine was noticed at L3 and L4 (Fig. 10d; marked with yellow circle) indicating contact between adjacent vertebral spinous processes.

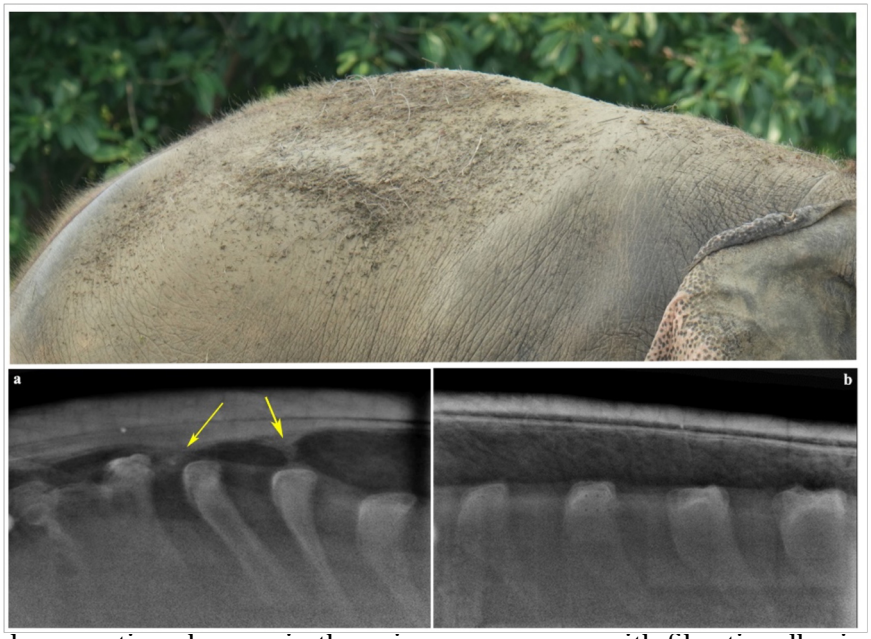

Figure 7. Mild degenerative changes in the spinous processes with fibrotic adhesions.

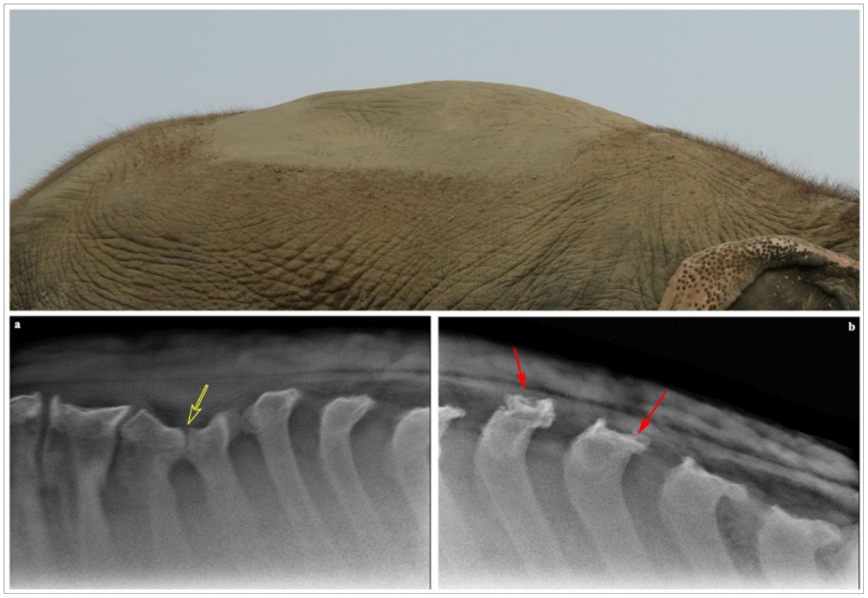

Figure 8. Remodelling of the dorsal spinous processes and abnormal callus formation.

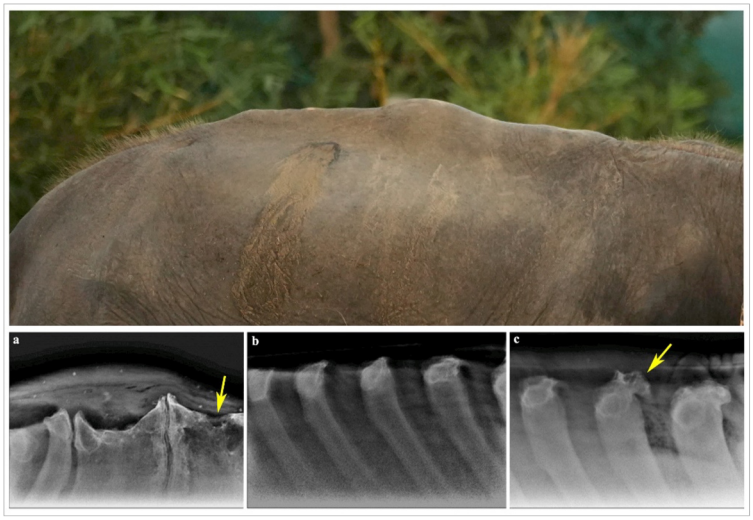

Figure 9. Abnormal degenerative and osteolytic changes in dorsal spinous processes.

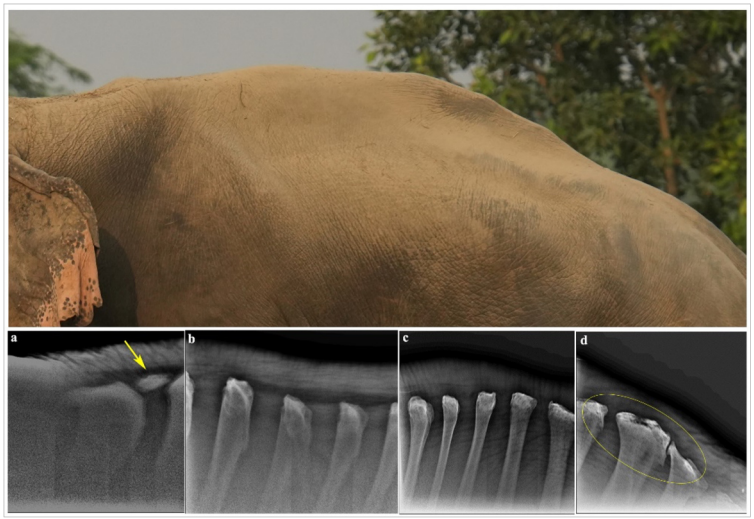

Figure 10. Degenerative lesions with kissing spine.

Discussion

As in African elephants (*Loxodonta africana*), the spinous processes incline caudally in Asian elephants (Bezuidenhout & Seegers 1996). Skeletal anatomy suggests that Asian elephants have 19 pairs of ribs and 33 caudal vertebrae (Mikota *et al*. 1994), whereas African elephants have 21 pairs of ribs and 26 caudal vertebrae (Smuts & Bezuidenhout 1993, 1994).

Kolk *et al*. (2008) assessed bone mineralization in captive Asian elephants through radiography of the tail vertebrae and concluded that there was a gradual increase in the level of mineralisation and closure of the epiphyseal growth plates as the elephants aged. At the age of 36 years, the growth plates were still not closed. Male and female feet mature at different rates and for different lengths of time in humans. The metatarsals and proximal phalanges, of females reach full maturity approximately 54 months earlier than do males (Whitaker *et al*. 2002). In elephants, the timing of P3 ossification for each digit is variable (Siegal-Willott *et al*. 2008). The relative times of growth plate closure were consistent between right and left feet, but they varied between the sexes. For example, one male elephant did not exhibit radiographic closure of the P1 growth plate until 8.7 years of age, in contrast to closure detected at 7.6 years of age in a female animal (Siegal-Willott *et al*. 2008). Thus, it suggests the elephant's skeletal system continues growing and the growth plate closing times differ for each bone.

Authors observation and available data from the present study revealed that growth plate mineralisation of dorsal spinous processes was encountered earlier in females (Fig. 11) as com-

pared to males (Fig. 12; marked with yellow arrows). Turner (2011) reported the occurrence of spinous impingement most commonly between T13 and T18 in riding horses. In the present study, the authors observed that the dorsal spinous processes of vertebra T1–T9 are more affected than T10–T19. This may be due to the pressure of saddle being more cranially than caudally because Asian elephants carry most of their body weight on their forelimbs (Panagiotopoulou *et al*. 2012).

With available data, even in elephants aged >50 years not showing complete closure of the growth plate (Fig. 13b, 14a & 14b, yellow arrows). However, elephants appear to be capable of carrying a significant amount of weight on the back without showing signs of physical distress and no significant evidence shows carrying a 15% body mass load brings changes in elephant gait patterns (Kongsawasdi *et al*. 2021). Any injuries that happen to the bones of the dorsal spinous processes before the closing of the growth plate may lead to various degrees of degeneration and fracture. The fragmented and partial avulsion of growth plates may lead to the fusion of the spinous processes due to further mineralization process.

Conclusion

Improper saddling, overloading, inappropriate use of cushion materials, and ignored health care of the wound along with malnourishment may result in damaging the spinous processes of the thoracic vertebrae which involves unusual

Figure 11. Female, 24 years, BCS 5/10, showing clear mineralisation; open physis at T8–T10 and T18–T19 (yellow arrows).

Figure 12. Male, 22 years, BCS 2/10, showing even epiphyseal growth plates at T11–T15.

fusion, various degrees of osteolytic changes, and remodelling. Hence any injury or saddle gall on the dorsal spine needs intensive treatment, otherwise the recurrent infection and consecutive damage will interrupt the wound healing. Later this becomes a chronic wound and increases the fibrotic adhesion with the dorsal spinous processes. Since all the elephants in this study are rescued from severely distressed conditions, it needs further investigations on healthy individuals who are not saddled to understand the exact time of growth plate closure of the spinous processes.

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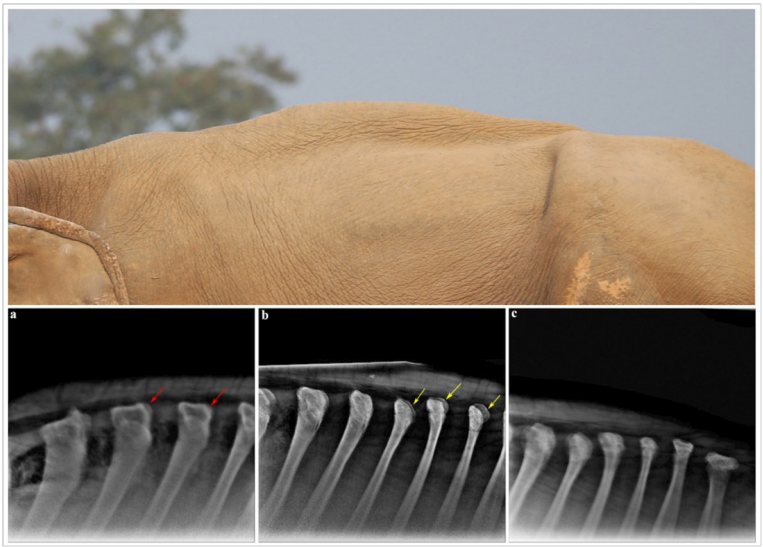

Figure 13. Male, 58 years, BCS 2/10, exhibiting partial mineralisation at T11–T13 (yellow arrows) and closure of growth plates at T5–T7 (red arrows).

Figure 14. Female, 67 years, BCS 2/10, complete closure (red arrows) of T13 and T14 vertebral growth plates, T16 and T17 yet to be closed (yellow arrows).

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