The sensitivities of various imaging modalities in detecting skeletal trauma in simulated cases of child abuse

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INTRODUCTION

- Physical abuse is a leading cause of child homicides worldwide.
- In 2018/2019, 18 644 assaults, 1 184 attempted murders and 1 014 murders, all involving children, were reported to the South African police [1].
- Skeletal trauma is common in victims of abuse but is often missed during autopsy.
- Various imaging modalities are used to aid in the identification of fractures.
- The aim was to compare the sensitivities of CT, X-ray and Lodox® scans, which are commonly used in South Africa, in detecting fractures in simulated cases of child abuse using a piglet model. The skeletonized remains were used as the gold standard for comparison.

MATERIALS & METHODS

- Ten piglets were, post-mortem, blindly subjected to blunt force trauma on the skull, thorax, fore- and hindlimbs (Fig. 1).
- Full body helical CT scans, X-rays of each body region, and full body Lodox® scans were taken.
- The number of fractures visible in each body region using each modality was recorded.
- Piglets were macerated, and the number of fractures present in each body region on the dry bone was recorded.
- The percentage of fractures detected by each radiological method with respect to the number of fractures detected on the dry bones was calculated.
- A two-way ANOVA was used to determine if any imaging modality differed significantly from dry bone for any body region.

Figure 1. Piglets were blindly struck on the skull, thorax, forelimbs and hindlimbs.

RESULTS & DISCUSSION

A total of 817 fractures were present on the dry bones, of which CT scans detected 531 (65%), X-rays detected 338 (41%) and Lodox® detected 291 (36%). The sensitivity of each modality for each body region is shown in Figure 2.

Most skull fractures missed were of the face and skull base (Fig. 3). The low sensitivity of all modalities is alarming since skull fractures are extremely common in victims of abuse [2].
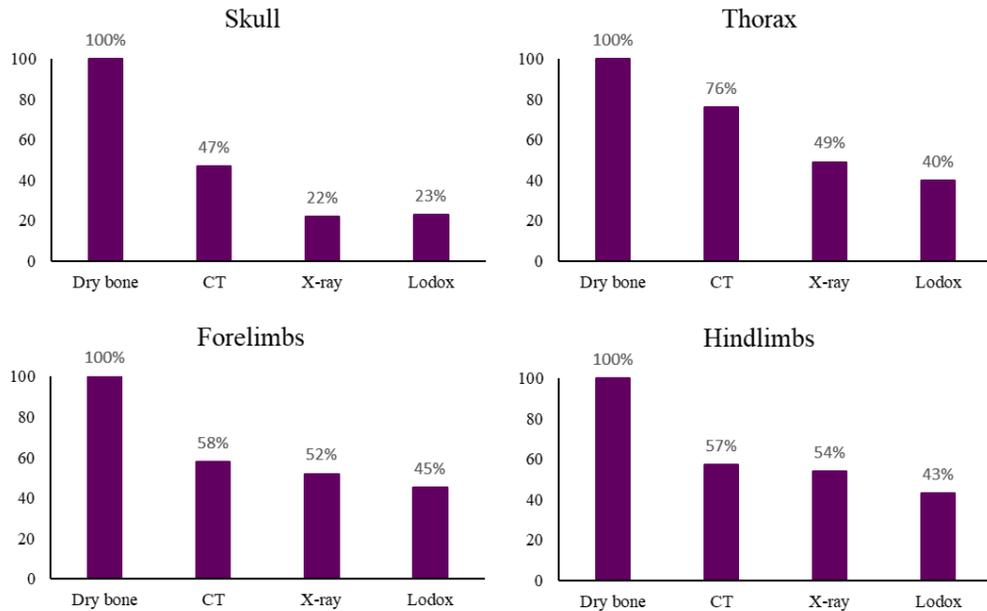

Figure 2. Comparison of percentage of fractures detected by dry bone, CTs, X-rays and Lodox® scans in each body region.
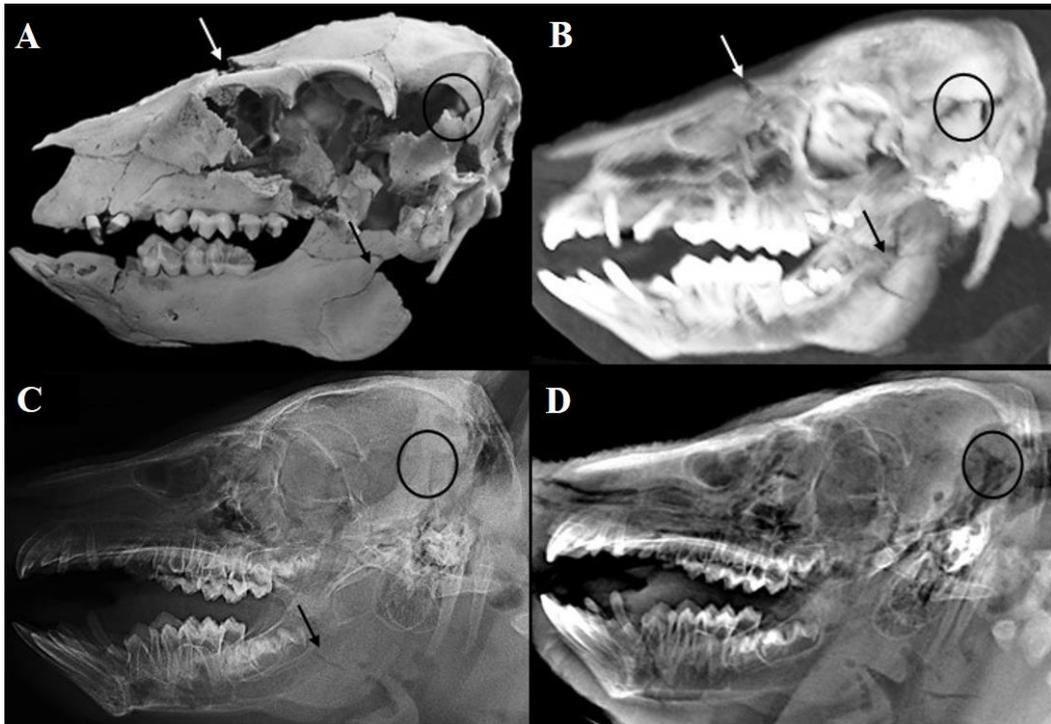

Figure 3. Parietal fracture (black circle) as seen on dry bone (A), CT (B), X-ray (C) and Lodox® (D). A fronto-nasal diastatic fracture (white arrow) is seen on dry bone (A) and CT (B), but not on X-ray (C) and Lodox® (D). A mandibular ramus fracture (black arrow) is also seen on dry bone (A), CT (B) and X-ray (C), but is not visible on Lodox® (D).

RESULTS & DISCUSSION (Cont.)

CTs mainly missed fractures of the sternal rib end, while X-rays and Lodox® scans missed most rib head and sternal end fractures (Fig. 4). These are some of the most common fractures seen in child abuse [2], and the low sensitivities of each method may mean that victims of abuse are not identified.

Most fore- and hindlimb fractures missed were those of the proximal and distal metaphyses of the long bones (Fig. 5). This is concerning since long bone metaphyseal fractures are highly specific for physical child abuse [3].

The two-way ANOVA showed that only CT fracture counts for the hindlimbs did not differ significantly from dry bone ($p > 0.05$).
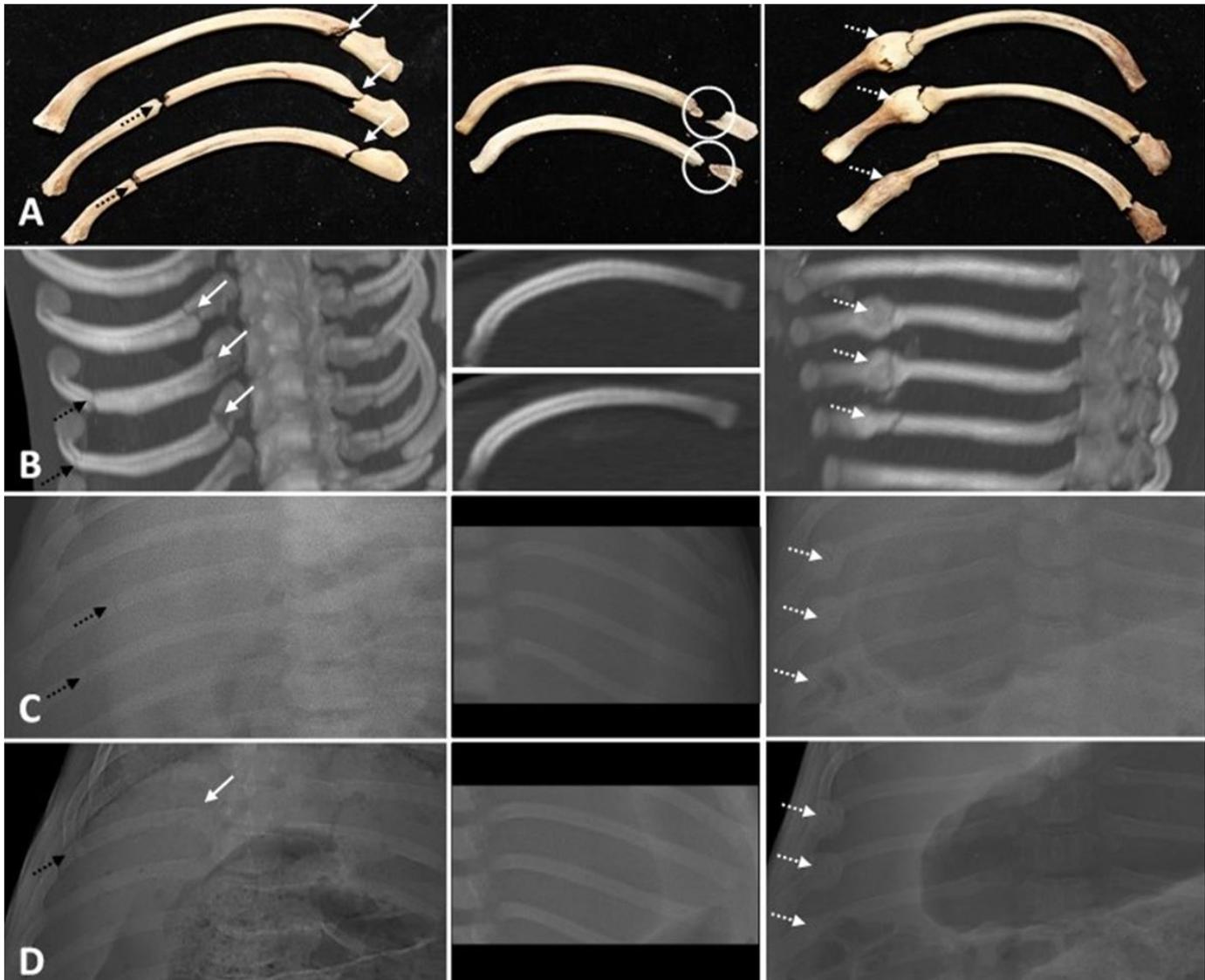

Figure 4. Posterior, sternal end and healed rib fractures (columns 1 – 3) of the same piglets as seen on dry bone (A), CT (B), X-ray (C) and Lodox® (D). White arrows indicate posterior rib fractures, most of which were not observed on X-ray and Lodox® scans. Fractures of the shaft (dashed black arrows) are detected but fractures of the sternal end (white circle) are often missed by CTs, X-rays and Lodox®. Almost all healed fractures (dashed white arrows) are identified by all modalities. The absence of any arrows or circles indicates no fracture detected.

Figure 5. Metaphyseal fractures (black arrows) of the distal ulna (top) and distal tibia (bottom) as seen on dry bone (A), but missed by CT (B), X-ray (C) and Lodox® scans (D). The absence of any arrows indicates no fracture detected.

CONCLUSION

Osteological analysis, when practical, should remain the method of choice when assessing suspected cases of child abuse. When not possible, such as in cases of the living, CT scans should be used. X-ray and Lodox® scans are not recommended for detecting fractures in suspected cases of physical child abuse.

REFERENCES

1. South African Police Services. Crime statistics: April 2018-March 2019. Pretoria: SAPS, 2019.
2. A.M. Kemp, F. Dunstan, S. Harrison, S. Morris, M. Mann, K. Rolfe, S. Datta, D.P. Thomas, J.R. Sibert, S. Maguire, Patterns of skeletal fractures in child abuse: systematic review, BMJ 337 (2008) 859-862. https://doi.org/10.1136/bmj.a1518
3. P.K. Kleinman, J.M. Perez-Rossello, A.W. Newton, H.A. Feldman, P.L. Kleinman, Prevalence of the classic metaphyseal lesion in infants at low versus high risk for abuse, Am. J. Roentgenol. 197 (2011) 1005-1008. https://doi.org/10.2214/AJR.11.6540