A Probable Case of Metastatic Cancer in Roman Austria: Exploring Ancient Health, Lifestyle, and Activity

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INTRODUCTION

Cancer is regularly described in archaeological contexts, with the oldest known human examples dating to the Neolithic and likely extending much further into the past (e.g., a reported hominin case from 1.7 million years ago[1-4]. To date, Roman cases of bone metastasis (cancer that has spread to the bone from another primary source) are reported from primarily older individuals from throughout the Roman world, including modern Austria and Hungary[5-7].

This poster presents a **differential diagnosis** of a **probable case of metastatic cancer** in the skeletal remains of a Roman male from *Carnuntum*, Austria (CA-187). As bone metastases are often associated with pain and other potentially-debilitating signs/symptoms (e.g., paresis, spinal cord compression, hypercalcemia, fatigue) that may lead to reduced activity and general unloading[8-10], we questioned if CA-187's **long bone cross-sections** exhibited any **evidence for disuse and unloading** in the months/years prior to their death.

MATERIALS & METHODS

Roman *Carnuntum* (modern Austria) (Fig. 1) consisted of a series of linked settlements: legionary and auxiliary forts and their associated civilian town to the east, and a large urban center (civilian) to the west. In 2008, CA-187 was excavated from the cemetery south of this large civilian city. Their remains were not *in situ* due to earlier site disturbances (e.g., grave robbers in antiquity); most elements were pushed against the North East end of the grave. The skeleton is represented by only 21 elements, most of which exhibit some post-mortem damage and fragmentation. CA-187 is estimated as a possible old adult male; they date to between the 1st and 4th centuries AD.

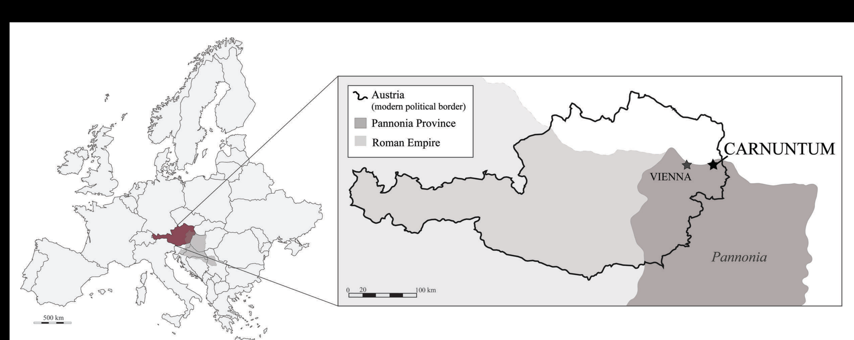

Fig. 1: Location of *Carnuntum*, modern Petronell-Carnuntum, Austria, ~40km east of Vienna. *Carnuntum* was the capital of the Roman province, Pannonia Superior, and situated alongside the south bank of the Danube river.

Anterior-posterior (AP) and medio-lateral (ML) diameters of the left radius and femur were used to approximate the bone's **total area** (TA) and a cross sectional **shape index (SI).**

- **Radius**: distal diaphysis, at the level where the superior aspect of the pronator quadratus meets the inferior margin of the flexor pollicis longus muscles.
- **Femur**: at the level of the proximal-most nutrient foramen, inferior to gluteal tuberosity

CA-187's radius was compared to 40 Romano-British males from Ancaster, UK (radiographic measurements)[11]. In a preliminary analysis, the left femoral measurements were compared to 10 males from *Carnuntum*. 'Normal' TA and SI ranges were identified as 1.5 times the interquartile ranges for each measure[12].

PATHOLOGICAL DESCRIPTION

A combination of osteo-blastic and lytic lesions throughout the post-cranial skeleton (Fig. 2).

- Axial skeleton involvement with lesions concentrated in pelvic girdle, spine, and shoulder. Lesions extend and dissipate as they progress away from the pelvic girdle/thorax and down the limbs.
- Spiculated new bone sits on top of and perpendicular to the sub-periosteal surface.
- New bone is packed within/between trabeculae and has infilled many medullary spaces.
- Lytic lesions perforate the cortex; periosteal new bone appears to form around the lytic structures.
- Exposed bone areas (e.g., proximal humerus) exhibit a soft 'moth eaten' appearance.
- Joints exhibit no pathological lesions.

DIFFERENTIAL DIAGNOSIS

Characteristics of bone metastases (after Macedo et al. 2017[10]):

- ✓ Osteolytic, osteoblastic, or mixed lesions
- ✓ Typically multi-focal and most frequently involving the axial skeleton
- ✓ Haematopoietic marrow may be involved in cancer spread (explaining the medullary hypertrophy with new bone and endocortical resorption at the metaphyses).

Clinically, prostate cancer is one of the most common cancers to metastasize to bone, typically causing blastic lesions in the pelvic girdle, lumbar spine, and proximal femur[10,13]. Metabolically active bone (with hematopoietic marrow) supports growth and survival of cancer cells and is a common location for prostate cancer metastasis[13]. Due to hematopoietic marrow involvement, trabecular microarchitecture changes (e.g., increase in trabecular number, connectivity and surface irregularity) have been observed in cases of prostate cancer bone metastasis[14,15].

Possible Disease	Evidence For	Evidence Against
Osteosarcoma	• Periosteal reaction typically sunburst pattern[16] • Cortical destruction[16]	• Most common in long bone metaphyses (dist. femur, prox. tibia/humerus), rarely involves axial skeleton[16-18] • Highly localized[17]; can metastasize (primarily to lungs)[18] • Most common between 15-25 years old, or associated with Paget's disease when >60 years old[19]
Thalassemia	• Marrow hyperplasia → osteopenia and endocortical resorption[20]	• Perpendicular hair-on-end bone formation *perforates* the skull's outer cortex[20] • Marrow hyperplasia → increased cortical reticulation[20,21] • Resorption of trabeculae → coarsened pattern[20] • Depending on the form of the condition, individual may not survive long without blood transfusions[21]

Stellate-like new bone formation on the pedicle, inside the neural canal

Perpendicular new bone formation sits on top of the sub-periosteal bone surface

FEMUR	**CA-187**	***Carnuntum*** **(Males, n=10)**
Total Area	605.5mm^2	517.4 - 836.2 mm^2 Median/Mean: 676.8mm^2 / 696.3mm^2
Shape Index*	0.92	0.84 - 1.08 Median & Mean: 0.96

*<1 = wider in ML than AP; >1 wider in AP than ML

Fig. 2: CA-187's skeletonized remains are depicted in all of the photographs above (skeleton arranged in anatomical position, with zoomed-in insets). Image directly above this caption is of the anterior surface of the sacrum. The spiculated new bone formation is evident, especially in the top left, where the perpendicularly-oriented new bone has formed in a stellate or sun-burst type pattern. Destruction of the cortex with a moth-eaten underlying appearance is evidence on the anterior of the sacral bodies and right ala.

Transverse view of mid-shaft right radius. The medullary canal is infilled with new woven bone. Cortex exhibits trabecularization at the endosteal surface with new bone formation within/between trabecular struts.

Lytic lesions on the left, proximal radius. Similar sub-circular lytic lesions present throughout the skeleton, concentrated at the long bone metaphyses.

CROSS-SECTION & ACTIVITY

CA-187's radius and femur TA and SI were **within normal ranges** for the comparative Roman samples. However, the measures were **below the comparative medians and means** and would merit further examination.

Bone metastases regularly cause pain, discomfort, and impairment (including paresis). Modern (treated) people with metastasised prostate cancer may survive a median of 6.6 years[22]. In individuals with considerable impairment (e.g., paralysis), subperiosteal bone loss may occur in as soon as two months of sustained inactivity[23,24]. Based on this, if CA-187 survived for more than a few months with this degree of metastasis, the cross-sectional evidence suggests that any activity deficits experienced were unlikely to be considerably impairing.

RADIUS	**CA-187**	**Ancaster, UK (Males, n=40)**
Total Area	128.7mm^2	104.7 - 190.8mm^2 Median/Mean: 147.8mm^2
Shape Index*	0.74	0.66 - 0.84 Median/Mean: 0.75

*<1 = wider in ML than AP; >1 wider in AP than ML

Limitations:

- Measurement locations apparently unaffected by periosteal new bone, but endosteal changes may influence the accuracy of cross-sectional estimates and prohibit accurate measurement of cortical thickness.
- Small femoral sample size; this will increase as research continues.

Next Steps:

- 3D surface scans → more reliably compare cross-sectional shape/area within the *Carnuntum* assemblage.
- SEM, X-Ray, CT, and microCT analyses to better characterize lesions.

CONCLUSION

The lesions and their distribution are consistent with a case of metastatic cancer, likely originating from the prostate. This represents **the first case to use shape to investigate palaeo-oncological activity repercussions**.

Although CA-187 likely experienced pain and discomfort (as well as other complicating symptoms) typically experienced by people with metastatic bone cancer, the preliminary cross-sectional geometric measures suggest that **CA-187's function was not significantly impaired or sufficiently sustained** to result in changes at the sub-periosteal bone envelope.

Please leave your thoughts, comments, and/or differential diagnoses!

ACKNOWLEDGEMENTS

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REFERENCES

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