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Integrity and characteristics of the bones of the Danish King St Knud (II) the Holy (†AD 1086)

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INTRODUCTION

The Danish King Knud (II) the Holy, one of King Svend Estridsen's numerous children, was probably born about 1043, and was thus about 43 years of age when he was murdered in 1086 after a six year reign. The scene of the murder was St Alban's Church in Odense on the Danish island of Funen, where King Knud, his half-brother Benedict, and 17 housecarls had taken refuge, after a band of men conscripted for war revolted against the King. Part of King Knud's strong assertion of royal power was based on his eager support of the Church. This cause was carried further when King Erik (I) Ejegod, one of King Knud's younger brothers and Danish king from 1095-1103, secured his canonization in the year 1100. An early legend about St Knud, *Passio sancti Kanuti regis et martyris,* tells that the King's bones were tested before he was declared a saint, and that, among other things, they were exposed to violent fire without being damaged (Gertz 1907). The priest Elnoth from Canterbury, who, some twenty years later, wrote the legend of St Knud (*Passio Gloriosissimi Canuti Regis et Martyris,* cf Albrechtsen 1986), stated that St Alban's Church was in possession of two capsules ("*capsulas*") with relics of St Alban and St Oswald, the former having been brought to Odense from England by King Knud. King Knud, says Elnoth, was mortally wounded, struck by a lance through his side, while Benedict, who fought by his half-brother's side, was literally cut to pieces. Elnoth ends with a description of how the bones of King Knud were wrapped in silk and laid in a shrine made of golden metal and decorated with gems. The shrine was placed on the altar in the new St Knud's Church in Odense (Johannsen *et al.* 1995; Vellev 1986).

A Russian prayer from about 1135 (Lind 1990; 1992) and another legend dealing with St Knud, the anonymous *Passio sancti Kanuti regis et martyris* dated to 1220-50 (Gertz 1912), both mention Benedict as a saint. The Iceland chronicle of kings from ca. 1250, *Knytlinga-saga* (cf. Knytlinga 1925) notes that both King Knud and Benedict were enshrined. It reports nothing about any ill treatment of Benedict, but says that King Knud was murdered with a sword after he had been hit with a stone on the forehead. Relics of St Knud and St Alban are referred to in 1183, and at the beginning of the 16th century Queen Christine gave offerings to the shrine of St Knud, a separate reliquary for St Knud's head, and a reliquary for St Alban's arm (Dronning Christines Hofholdningsregnskaber 1904).

From then on and until 1582 the fate of the shrines is unknown. But around 1582 St Knud's Church was being rebuilt, and on 22nd January 1582 St Knud's shrine was brought to light, presumably from a hiding-place in the choir (Dania Chorographia 1591; Otonium (1597) 1981; Konninck 1603; cf. Gertz 1907). The shrine, which held a couple of inscriptions denoting it as St Knud's shrine, was described as an oak coffin with metal furnishings and rock crystals, lined by thin, brown silk. The bones were wrapped in costly clothes. Although many people saw the shrine, it is uncertain when it was walled up again. Two Flemish monks who visited Denmark in 1622 asserted that they had seen the fragments of the skull of St Knud, but it is uncertain whether they also saw his shrine (Janssenius & Brouwer 1622; Wieselgren 1961). Around 1694, while the church was under repair, some artisans discovered a bricked-up cavity above a niche in the southern part of the eastern wall. Both shrines were concealed in this cavity (Forskellige stykker 1696; Bircherod 1743; Bircherod 1773; cf. Gertz 1907). This time, however, they were found robbed. Almost every bit of the furnishings had been torn off, one of the shrines had lost its lid completely, the other had lost part of its lid, and as both shrines were placed on end, bones and clothes from each had fallen out and were now partly intermingled. As there was no inscription left to identify St Knud's shrine, the scholars present at the event decided that the shrine with the partially preserved lid was that of the King.

In 1696 the shrines were once more walled in, and in 1833 they were brought to light for the last time (Paludan-Müller 1833). Since then they have had their place in the church, on public display. In 1874-75 the shrines were restored and their contents distributed between the two shrines by a committee set up to estimate the age and historical backgrounds of the skeletons (Helgenskrinene 1886). This sorting of the bones was not as complicated as might be envisaged because of the apparent age difference between the two skeletons (aged about 40 and 20 years respectively). Most of the committee members agreed that King Knud's shrine was the one without a lid. This had hardly any furnishings left, but – contrary to the shrine with a fragment of lid – it bore traces of having been lined with red-brown silk. Since 1875, the shrines have been kept in the crypt of St Knud's Church and the identities of the skeletons and the correctness of their distribution have occasionally been questioned and discussed ever since. Is it really King Knud who lies in the lidless shrine? Do all the bones in this shrine belong to the same individual? As to the other shrine, the essential question has been the identification of the skeleton. Several scholars have pointed out that it must be St Alban (Petersen 1886; Steidl 1908). One scholar has drawn attention to an English legend according to which the skeleton of St Alban had at one time been kept in Denmark, but parts of it were smuggled out again at a later time (Petersen 1886). Another group of scholars have adhered to the opinion that St Knud's Church originally only possessed a minor part of St Alban, and that the skeleton in the other shrine is that of Benedict (Jørgensen 1887; Damgaard 1891; Gertz 1912); an opinion consistent with the findings of this study. Benedict is known to have been King Knud's younger half-brother, which agrees well with the skeletal age determination (18-20 years) of the bones. A recent theory claims that the other skeleton could be that of King Erik (III) Lam born *c.* 1110, who died as a monk in the Monastery of St Knud in 1146 (Langberg 1992), a theory which is inconsistent with the present findings.

The shrine without a lid has been dated by dendrochronology (Bonde *et al.* 1994). Three samples were dated, but sapwood was not preserved in any of them. The results showed that the shrine had definitely been made after AD 1074 and probably before AD 1100, the year of King Knud's enshrinement. The shrine with remnants of a lid will have to be disassembled before it can be dated by dendrochronology, and it has therefore been decided to postpone this step until the shrine is to be restored some time in the future. Based on stylistic criteria, however, the shrine with a piece of the lid can be dated to about AD 1050-75. In the light of this, and based on the remnants of red-brown silk still visible inside the lidless shrine, it must be considered likely that this was the shrine made for the body of King Knud just before AD 1100. It is beyond any doubt identical with the shrine found and identified as that of King Knud's in 1582. What remains to be discussed is the question of the identity of the skeletons.

THE SKELETON

King Knud's shrine contains an almost complete, well preserved skeleton, which has been described in a previous study (Tkocz & Jensen 1986). The results of our re-examination are in general identical to the observations of Tkocz & Jensen (1986).

The skeletal remains can briefly be described as rather well proportioned, with an approximate stature of 178 cm, which is more than the average male stature in the Viking period (171 cm) and the Middle

Ages (173 cm). The relatively tall stature may be linked to a high social rank having provided optimal conditions for growth and development.

Two thoracal vertebral bodies are wedge-shaped, probably a congenital phenomenon (Morbus Scheuermann) which X-ray pictures seem to confirm, rather than the effect of osteoporosis. The bone mineral content of the femoral diaphyses, measured with a dual photonabsorption scanner, was very low indeed, 4.08 g/cm, compared to the average values in contemporary Danish men, 5.40 g/cm, and Viking Age/Medieval male skeletons, 4.88 g/cm (Bennike & Bohr 1990). King Knud's low bone mineral content value for the femoral bones could be an expression of little or no heavy physical exertion.

In the following, we have chosen to focus on the essential disparities between the results of the abovementioned previous study and our re-examination and on clarifying: 1) whether the cranium and the rest of the skeleton belong to a single or two individuals, 2) whether so-called lesions on the cranium and on the sacrum were induced pre- or postmortem and 3) how the lesions were induced.

AGE DETERMINATION OF THE SKELETON

In general, ossification of the cranial sagittal suture begins posteriorly at the age of 20-40 years, and is completed anteriorly at 40-50 years. Ossification of the coronal suture begins centrally at 40-50 years and is only completed later in life. Both the anterior part of the sagittal suture and the whole coronal suture are clearly visible on the cranium, indicating an age of 30-50 years. Degenerative signs were found in the form of beginning osteophyte formations around the auricular surfaces and some of the costo-vertebral joints, which also indicates that the individual was between 30 and 50 years of age. Together with an examination of the costo-sternal end of the ribs and of the pubic symphysis, an estimation of the age (Bass 1987) can be summed up as:

Cranial sutures:	30-50 years m = 40 years
Costal ends (Phase V):	33-42 years m = 38 years
Pubic symphysis (Phase IV):	23-57 years m = 40 years
Osteoarthritis:	30-50 years m = 40 years

This points to an average age of 40 at the time of death; most likely the individual was between 35 and 45 years of age.

Fig. 1. a) Cranium of King Knud. Front view, b) Side view. Note the 6.6 cm long crack on the left side of the frontal bone.

THE CRANIUM AND THE CRANIAL DEFECTS

The surface of the cranium is slightly brown and has peeled off in places, which means that it has either been lacquered or treated with a preservative some time in the past. The remaining bones are the frontal bone, the left and right parietal bones and the occipital bone. The squamosal sutures delimit both the parietal bones. The internal lamina of the cranium shows distinct imprints of vessels, but without any traces of aneurysms, which are most common in elderly individuals. Although the external occipital protuberance (to which the muscles of the neck are attached) is not prominent, the well-developed brow-ridges and sloped forehead indicate a male cranium.

The few obtainable cranial measurements are listed below (Martin & Saller 1957):

M 29 nasion-bregma:	10.6 cm
M 30 bregma-lambda:	11.2 cm
M 9 min. frontal width:	9.1 cm
M 8 max. width:	13.6 cm
M 1 max. length:	18.0 cm
Width/length index:	75.6 (mesocephalic)

The cranial capacity could not be determined, but as all the measurements are smaller than the averages for Danish male skulls from several prehistoric periods, the capacity of this skull cannot have been very large.

In an earlier study of the skeleton, Tkocz & Jensen (1986) concluded that there is a lesion on the left side of the frontal bone, supposedly caused by a sharp weapon. Our re-examination of the left side of the frontal bone only revealed a 6.6 cm, slightly curved, vertical crack without sharp edges (see Fig. 1). No signs of bone reaction (healing processes) could be seen at the crack. In our opinion, this crack is hardly the result of an attack with a sharp weapon. If the crack is the result of an act of violence, it must have been caused by a blunt instrument. A stone, as claimed by the Knytlinga saga (1925), could possibly have caused such a lesion. From below, it runs from the edge of the sphenoid bone, almost straight through the temporal line and continues to approximately the middle of the coronal suture. An indentation caused by postmortem erosion surrounds the widest end of the crack. The right side of the frontal bone exhibits a similar, though less eroded indentation in the corresponding area. These particular areas of the cranium are often very thin, and it seems likely that the crack is a consequence of postmortem erosion. However, there are other less well-defined eroded areas on the cranium, e.g. a 1.2 x 1.5 cm area on the right parietal bone at the lambdoid suture, which we also assume to be due to postmortem erosion.

THE SACRUM AND THE SACRAL LESIONS

The well-preserved and intact sacrum has a slightly brown colour and has most likely been lacquered or treated with a preservative. Interestingly enough, it shows both male and female characteristics: a protruding promontory and a sharp curvature at the 3rd sacral vertebra. The sacrum is rather small and wide, which is atypical in the male, but it is also relatively massive.There is no doubt that the sacrum, the rest of the pelvic bones (ossa coxae) and the femora belong to one and the same individual, most probably a male. The uppermost articular surface of the sacrum is slightly larger than one third of the total width, but cannot be considered excessively large. The auricular surfaces of the sacrum are not symmetrical. The left surface is irregular with a small bone protuberance at the upper, forward articular edge and has a porous spot (2 x 1 cm) in the middle. For obvious reasons this area was not included in the skeletal age determination. The uppermost segment of the coccyx is fused with the sacrum at an angle of 145°.

The sacral measurements are:

Diameter (max.) of the upper joint surface of the 1st sacral vertebra (basis ossis sacri):	4.6 cm
Width of sacrum (max.):	11.3 cm
Vertical length (max.):	9.2 cm
Depth (max.):	3.3 cm
Length of auricular surface:	5.9 cm

(Definitions: W.Bass 1987, p.108).

On the ventral sacral surface of the 3rd sacral vertebra (Fig. 2), there is a 3.5 cm long horizontal fracture, most likely a lesion, with fractured surfaces that

Fig. 2. Ventral surface of the sacrum of King Knud. Note the 3.5 cm long horizontal fracture on the ventral sacral surface of the 3rd sacral vertebra.

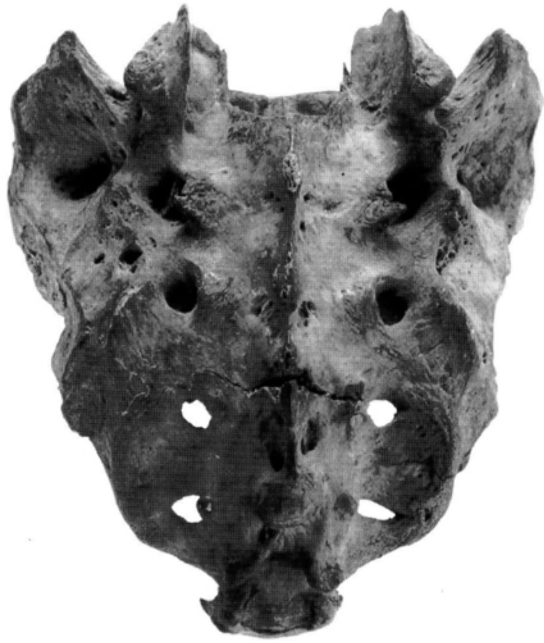

Fig. 3. Dorsal surface of the sacrum of King Knud. Note the vertical, wedge-shaped 4 mm wide and 15 mm long, horizontal crack in the median crest at the 3rd dorsal sacral foramen.

do not show any signs of bone reaction. The fracture line runs down to the 3rd right sacral foramen, continues to the 4th right sacral foramen and on to the right edge of the bone. In the centre of the fusion between the 3rd and 4th sacral vertebrae there is a small smooth bone formation. This is presumably a natural ossification and thus insignificant.

On the dorsal sacral surface (Fig. 3) there is a vertical, wedge-shaped 4 mm wide and 15 mm long, horizontal crack in the median crest of the sacrum at the 3rd dorsal sacral foramen. Fracture lines run in both directions to these foramina. To the right of and slightly below the 3rd sacral foramen one sees a 2 mm long fracture line with an aperture of 1 mm. This fracture ends 1 mm from the right edge, 22 mm above the fracture line on the ventral sacral surface.

It is very difficult to imagine how this lesion could have been caused by a frontal attack with a lance as proposed by Tkocz & Jensen (1986). The weapon would have had to enter the body from below, at an angle of 140° in relation to the axis of the body, and at an angle of 100° in relation to the axis of the two uppermost sacral vertebrae. The lance would thus have to have caused serious damage to the sacrum, leaving smooth but sharp marks on the bone, which, however, were not observed. Regardless of whether King Knud was standing, sitting, kneeling or lying down when attacked, the weapon could not have entered the body at the stated angles without producing lesions on the fused coccyx/sacrum or on the pubic bone, none of which are seen. The wedge-shaped crack on the dorsal sacral surface does not show any sign of having been induced by a sharp weapon. There is spongoid bone tissue along its edges and there is no evidence of bone reaction in the surrounding area. The most likely explanation is that the crack was due to a compression of the sacrum resulting in a 105° curvature. We therefore assume that the lower part of the sacrum was exposed to some kind of sudden and extreme pressure slightly left of centre, causing the sharp curvature, which in turn caused the wedge-shaped crack (Fig. 4). This could happen if the King was in a kneeling position, and as there are no traces of a sharp weapon, the lesion must have been the result of a blow with a blunt instrument, *e.g.* a club. A violent blow would probably crush the bone,

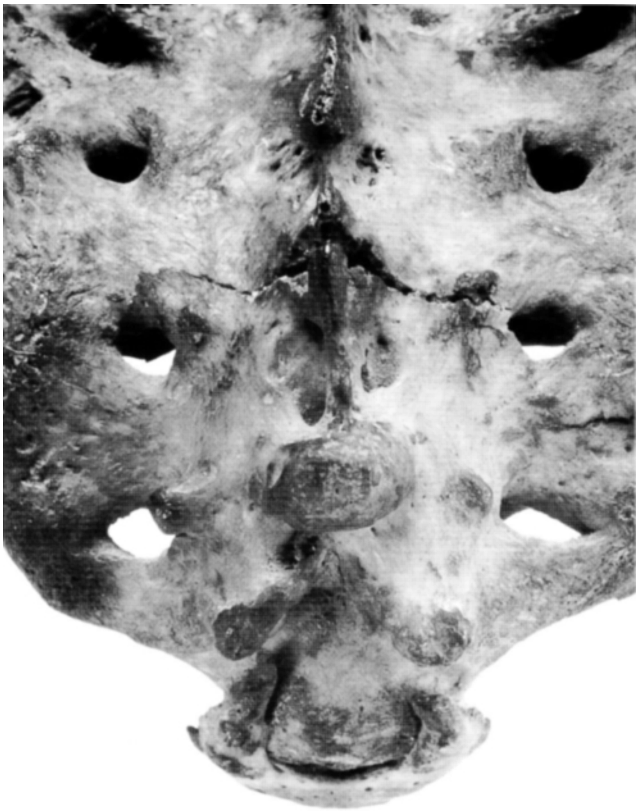

Fig. 4. Dorsal surface of the sacrum of King Knud. Note the wedge-shaped crack.

but posteriorly, soft tissue could have had a cushioning effect. Another, perhaps less likely, possibility is that the lesion could have been induced shortly before or after death by a fall from a certain height.

The King was interred after his death, but his skeleton was finally moved back to the church 30 years later, and one cannot completely exclude the possibility that the sacrum was compressed in the interim when the bones were displaced. In this case the sacrum would have to have been in an upside down position with the upper vertebra pointing downwards. However as the bone would have been dry by this time, it would more likely have been crushed.

CARBON-14 DATING

A 1.5 gram sample was taken from the posterior part of the tibia of King Knud for the purposes of trace element chemical analysis and radiocarbon dating. The bone was reconstructed in plaster, so that the sampling location is now barely visible. On Benedict a 1.0 gram sample of the left femur was taken for both radiocarbon dating and trace element analysis. The outer parts (~ 1 mm) of the bone samples were removed with a scalpel prior to further treatment.

Collagen was extracted from the bone samples in the standard way used in the Copenhagen Radiocarbon Dating Laboratory (Mook & Waterbolk 1985: 40). The carbonate and hydroxyapatite were dissolved in an excess of 1.8 M HCl. The samples were then washed in demineralized water, followed by hydrolyzation of collagen in 0.001 M HCl. Insoluble residues were removed by centrifugation, and the collagen samples were dried at 120°C for at least 50 hours.

Approximately 14 mg of collagen was then sealed in an evacuated quartz tube together with 0.3 g CuO and heated to 800°C for 10 minutes, thus converting the carbon in the collagen to CO_2. Constituents other than CO_2 were removed in our Accelerator Mass Spectroscopy (AMS) preparation line by freezing with dry ice and acetone, and a small sample was extracted at this stage for $\delta^{13}C$-measurements carried out on a Micromass double focusing mass spectrometer situated at the Geological Institute at the University of Copenhagen, Denmark. The rest of the sample was then converted to graphite at 650°C on a Co-catalyst placed in a quartz tube, which was subsequently evacuated and sealed. Prior to graphitation the Co-catalyst was preheated at 450°C in a H_2-atmosphere for 1 hour. The graphitation process was continued until more than 95% of the CO_2 had been converted to graphite. AMS measurements were carried out at the AMS-facility at Aarhus University, Denmark. The ^{14}C-activity of the sample was referred to the oxalic acid standard prepared in the same reactor of our AMS preparation line.

The results of the datings are listed in Table 1. The calibration into calendar years has been carried out with the 20 years averaged atmospheric calibration curve from 1998 using the University of Washington Calibration program Calib version 4.0 (Stuiver *et al.* 1998). The resulting distribution of calendar years is shown in fig. 5. It is apparent that both dates are in accordance with a death in AD 1086.

The radiocarbon dates exclude the possibility that

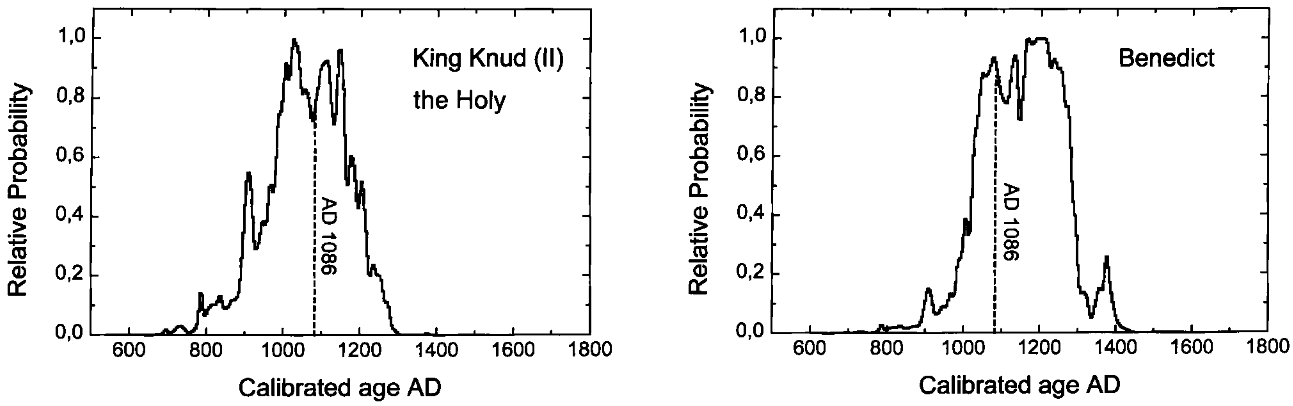

Fig. 5. Distribution of calibrated radiocarbon dates of King Knud and Benedict. The radiocarbon dates have been calibrated according to the 20 years averaged atmospheric curves given in Stuiver & Pearson (1998).

the bones could have belonged to either the Holy St Alban (died *c.* AD 305) or the Holy St Oswald (died *c.* AD 642). From the radiocarbon dates alone it cannot, however, be excluded that either individual could be from AD 1146, the year that King Erik (III) Lam died in the Monastery of St Knud in Odense. It is, however, not very likely that King Erik (III) Lam, who was a monastic scholar, could have received the lesions observed on both skeletons.

CHEMICAL ANALYSIS

In order to elucidate the question of the integrity of the skeleton of King Knud, a 0.5 gram sample was taken from the left basal part of the cranium. This sample, together with an aliquot of the sample from the tibia from King Knud and the femur of Benedict, was subjected to Instrumental Neutron Activation Analysis (INAA).

Two sub-samples were irradiated in the Danish heavy water reactor DR-3 at Risø in a neutron flux of 3 10^{13} cm^{-2} s^{-1} for 20 hours. Subsequently the samples were counted three times on a high purity Ge (germanium)-detector and the concentrations of Na (sodium), K (potassium), Ca (calcium), Sc (scandium), Fe (iron), Co (cobalt), Zn (zinc), Br (bromium), Sr (strontium), Ag (silver) and Au (gold) were determined. The analytical errors are typically within ± 10%. Two other sub-samples were irradiated in the Triga-reactor in Vienna in a neutron flux of 5 10^{12} cm^{-2} s^{-1} for 10-20 seconds and analyzed for shortlived elements. The concentrations of F (fluorine), Cl (chlorine), Al (aluminium), Mg (magnesium), V(vanadium) and Mn (manganese) were determined by short irradiations. The analytical errors for the elements

Lab. No	Other Id.	Material	δ13C o/oo VPDB	^{14}C-age (BP)	Cal. Date AD	Cal. Date at ±1 σ
K-6141	NNU A-7348 AAR-1494	Femur of Benedict	-19.0	860±120	1190-1210	AD 1020-1280
K-6142	NNU A-7348 AAR-1495	Tibia of St Knud	-18.3	985±100	1020	AD 980-1160

Table 1. Results of the radiocarbon dating. The samples were pre-treated and graphitized at the Radiocarbon Dating Laboratory in Copenhagen and measured by AMS at the accelerator facility at University of Aarhus. Preservative materials were removed prior to dating. The $\delta^{13}C$ analyses were performed at the Geological Institute, University of Copenhagen. Calibration was carried out using the 20 years averaged atmospheric curve (Stuiver *et al.* 1998).

determined by the short irradiations are typically within ± 15%. The results are given in Table 2.

Figure 6 shows the abundances normalized to the average of 40 historic and prehistoric Danish bones. The figure also shows the ± 2 standard deviation variation interval, which constitutes the interval of normal variation for each element for the 40 historic and pre-historic bones. It is evident from fig. 6 that all elements analyzed are within the ± 2 standard deviation intervals with only one exception, namely Au, which is significantly higher in the cranium than in the tibia. For the other elements the variational patterns of the cranium and the tibia are very similar. Excluding Au (gold), this implies that there is no reason to assume that the cranium and tibia belong to different individuals.

Gold is an element that is ubiquitous in both churches and laboratories, but even so, we consider the difference between the cranium and the tibia so large that a specific explanation is called for. The only plausible explanation we can offer for the increased Au-abundance in the cranium is that it stems from carrying the cranium of King Knud around the city of Odense in a reliquary in the Middle Ages. Such reliquaries were often gold plated on the inside, and it is known that Queen Christine did in fact donate a separate reliquary for King Knud's head (Dronning Christines Hofholdningsregnskaber 1904; Braun 1940). Even though we removed about 1 mm of the outer parts of the bone samples in order to avoid contamination, we consider it likely that particularly the back of the cranium, which was sampled for this study, was somehow contaminated with Au in the reliquary.

CONCLUSIONS

1 Trace element analyses imply that in all likelihood the cranium and tibia of the skeleton in King Knud's shrine belong to the same individual.
2 Based on the anthropological re-examination of the skeletal remains of King Knud, it can be stated that in all probability the remains are from the same individual, although the anthropological results alone are inconclusive. The suggestion that the skull is significantly younger than the rest of the skeleton (Tkocz & Jensen 1986) can however be repudiated.
3 Based on several age determination criteria, we conclude that King Knud was 35-45 years old at the time of his death.
4 The radiocarbon dates are in accordance with a death in AD 1086 for both skeletons, as would be expected for King Knud (II) the Holy and his half-brother Benedict.
5 The radiocarbon dates exclude the possibility that the bones could be the remains of either St Alban or St Oswald, but it cannot be excluded that either of the skeletons might be that of King Erik (III) Lam, who died in AD 1146. It does not, however, seem likely that King Erik (III) Lam could have received the lesions found on both skeletons.

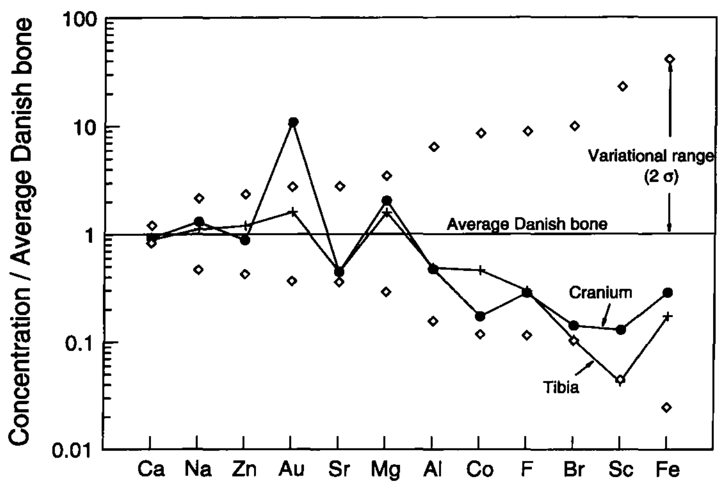

Fig. 6. Abundances of trace elements in the cranium and tibia of the bones in King Knud's shrine normalized to the average of 40 historic and prehistoric Danish bones. Also shown: the ±2 standard deviation variation interval for each element. Note the co-variance of the two samples, with the exception of Au (gold).

	Tibia	Cranium	Cra/Tib
	µg/g	µg/g	
F	494	470	0.95
Na	5110	5980	1.17
Mg	3450	4470	1.30
Al	206	200	0.97
Cl	679	2190	3.23
K	< 1470	1650	> 1.12
Ca	236000	246000	1.04
Sc	0.00148	0.0045	3.06
V	< 0.14	0.296	> 2.11
Mn	779	378	0.49
Fe	36.2	60.1	1.66
Co	0.136	0.0508	0.37
Zn	133	97.4	0.73
Br	2.47	3.33	1.35
Sr	118	118	1.00
Ag	< 0.14	0.476	> 3.40
Au	0.0114	0.0772	6.77

Table 2. Results of the INAA on the skeleton in the shrine of King Knud (II) the Holy, Odense. Both tibia and cranium were analyzed. The elemental ratios between cranium and tibia are listed as well.

6 Whether the lesion on the left side of the cranium is the result of a pre- or postmortem episode could not be established with any certainty. If the lesion was induced by an act of violence shortly before or after death, it must have been inflicted with a blunt instrument, as the cranial fracture shows no sharp edges. However, several thin areas of the skull exhibit signs of advanced erosion, indicating that the crack could be due to postmortem damage.

7 The fractured sacrum does not show any signs of bone reaction either. Even though it cannot be ruled out that the fracture was induced by a fall, pre- or postmortem, we consider it more likely that the fracture of the sacrum was caused by a blow with a blunt instrument shortly before or after death.

8 It is highly unlikely that the lesion of the sacrum was caused by a lance as proposed by Tkocz & Jensen (1986). The lance would have caused serious damage to the sacrum, leaving smooth but sharp marks on the bone, which was not observed. A lance entering at the required angle would also produce lesions on the fused coccyx/sacrum or on the pubic bone, none of which are evident.

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REFERENCES

Albrechtsen, E. 1986: Elnoths krønike. In: T. Nyberg, H. Bekker-Nielsen & N. Oxenvad (Eds.): *Knuds-Bogen 1986. Studier over Knud den Hellige.* Fynske Studier XV, Odense bys Museer, Odense, pp. 21-60.

Bass, W.M. 1987: *Human Osteology.* 3rd ed. Missouri Archaeological Society.

Bennike, P. & H. Bohr 1990: Bone Mineral Content in the Past and Present. In: Eds. C. Christiansen & K. Overgaard (Eds.): *Osteoporosis,* 1, pp. 89-91.

Bircherod, T. 1743: Annotiones in libellum quem Elnothus monachus canturiensis, de vita, et passione Canuti. *Monumenta inedita rerum germanicarum præcipue Cimbricarum et megapolensium* (ed. Ernst Joachim de Westphalen), tom IV, Leipzig, pp. 1378-1439.

Bircherod, T. 1773 (Ed. C.G. Biering): *Kong Knud den Helliges Historie, forfattet af Thomas Broder Bircheroed*. Odense.

Bonde, N., Th. Bartholin, K. Christensen & O.H. Eriksen 1994: Dendrochronological dating at the National Museum of Denmark 1993. *Arkæologiske udgravninger i Danmark* (AUD) 1993, pp. 294-310.

Braun, J. 1940: *Die Reliquiare. Des christlichen Kultes und ihre Entwicklung,* Freiburg im Breisgau.

Damgaard, A.K. 1891: Om Benedicts skrin i St Knuds kirke i Odense. *Kirkehistoriske Samlinger,* 4. rk. I, pp. 244-67, 1889-1891.

Dania Chorographia 1591 Københavns Universitet, Den arnamagnæanske Samling, Håndskrift nr. AM 852, 4°.

Dansk kunsthistorie 1972: I, Copenhagen: 24-25.

Dronning Christines Hofholdningsregnskaber 1904: Ed. William Christensen, Copenhagen.

Forskellige stykker til den danske choreographie 1696: Royal Library Copenhagen, *Ny Kongelig Samling,* 647, 4°, pp. 7f.

Gertz, M.C. 1907: *Knud den Helliges Martyrhistorie,* Copenhagen 1907.

Gertz, M.C. 1912: *Vitae Sanctorum Danorum,* Copenhagen 1908-12.

Helgenskrinene i Sankt Knuds kirke i Odense, undersøgte 1833 og 1874 1886: Ed. Ministeriet for Kirke- og Undervisningsvæsenet, Copenhagen 1886.

Janssenius, N. & J. de Brouwer 1622: *Itinerarium Danicum.* Royal Library, Copenhagen. *Ny Kongelig Samling,* 2851, 4°.

Johannsen, B.B., H. Johannsen & U. Kjær 1995: *Danmarks Kirker,* Odense amt, hft. 5-7, Poul Kristensen, Herning.

Jørgensen, A.D. 1887: Helgenskrinene i St Knuds kirke. *Aarbøger for Nordisk Oldkyndighed og Historie* (1886): 204-14, and *Aarbøger for Nordisk Oldkyndighed og Historie* (1887), pp. 125-170.

Knytlinga 1925: Ed. Carl Petersen & Emil Olson, *Sogur Danakonunga* (Samfund til Udgivelse af gammel nordisk Litteratur). Copenhagen 1919-1925.

Konninck, J. 1603: *Ausstzug vndt summa aller Könnige in Dennemarcken, Regiment, Kriegsswesen, vndt Leben, von dem Ehrsten Konige Dan, biss auff Königk Christianum den Vierten.* Royal Library, Copenhagen. *Ny Kongelig Samling,* 889, 4°.

Langberg, H. 1992: Knud den Hellige og Erik Lam. Newspaper article in *Fyens Stiftstidende* May 23th, 1992.

Lind, J.H. 1990: The Martyria of Odense and a Twelfth Century Russian Prayer. *Slavonic and East European Review,* 68(1), pp. 225-263.

Lind, J.H. 1992: De russiske ægteskaber. Dynasti- og alliancepolitik i 1130'rnes danske borgerkrige. *Historisk Tidsskrift,* 92(2), pp. 1-21.

Martin, R. & K. Saller 1957: *Lehrbuch der Anthropologie.* 3rd ed. Stuttgart.

Mook, W.G. & H.T. Waterbolk 1985: Handbook for Archaeologists No. 3, *Radiocarbon Dating,* European Science Foundation, Strasbourg.

Otonium. Odense 1593: In: Georg Braun & Frans Hogenberg (1597) *Civitates orbis terrarum,* V, 30, Cologne. Edition by Ove Jørgensen. Odense, 1981.

Paludan-Müller, C. 1833: Om Knud den helliges relikvier. *Nordisk Tidskrift for Oldkyndighed,* II, pp. 193-223.

Petersen, H. 1886: St Albans relikvier i Odense. *Aarbøger for Nordisk Oldkyndighed og Historie,* pp. 369-402.

Steidl, P. 1908: *St Albans Helgenskrin,* Odense.

Stuiver, M., Reimer, P.J., Bard, E., Beck, J.W., Burr, G.S., Hughen, K.A., Kromer, B., McCormac, F.G., v.d. Plicht, J. & Spurk, M. 1998: INTCAL98 Radiocarbon age calibration, 24,000-0 cal BP. *Radiocarbon* 40, pp. 1041-1083.

Tkocz, I. & K.R. Jensen 1986: Antropologiske undersøgelser af skelettet i skrinet med de snoede søjler. In: T. Nyberg, H. Bekker-Nielsen & N. Oxenvad (Eds.): *Knuds-Bogen 1986. Studier over Knud den Hellige* , Fynske Studier XV, Odense bys Museer, Odense, pp. 117-122.

Vellev, J. 1986: Helgenskrinene i Odense - fund og forskning 1582-1986. In: T. Nyberg, H. Bekker-Nielsen & N. Oxenvad (Eds.): *Knuds-Bogen 1986. Studier over Knud den Hellige.* , Fynske Studier XV, Odense bys museer, Odense, pp. 123-56.

Wieselgren, J.P. 1961: Itinarium Danicum. En resa i Danmark och Skåne 1622. *Historisk Tidsskrift,* 29(2): 369-81.