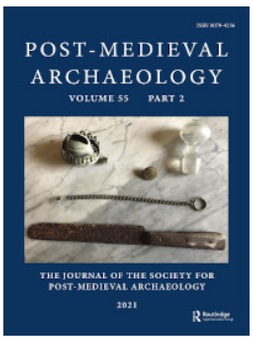

Post-Medieval Archaeology

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/ypma20

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To cite this article: Rebecca Crozier, Alison Cameron, Bruce Mann, Elizabeth Ashcroft & Rachel Wood (2021) Osteoarchaeological evidence for medical dissection in 18th to 19th century Aberdeen, Scotland, Post-Medieval Archaeology, 55:2, 159-175, DOI: 10.1080/00794236.2021.1972584

To link to this article: https://doi.org/10.1080/00794236.2021.1972584

Published online: 07 Oct 2021.

Post-Medieval Archaeology **55/2** (2021), 159–175

Osteoarchaeological evidence for medical dissection in 18th to 19th century Aberdeen, Scotland

By REBECCA CROZIER, ALISON CAMERON, BRUCE MANN, ELIZABETH ASHCROFT *and* RACHEL WOOD

SUMMARY: This paper describes the analysis of a small assemblage of fragmentary human remains discovered during renovations in a residential property in Aberdeen City, Scotland. Two sets of cranial remains display clear evidence for dissection/autopsy activities; a craniotomy and a trephination. Radiocarbon dating places them in the late 18th and early 19th centuries, arguably contemporary with the passing of the Anatomy Act of 1832. Drawing together evidence from osteological analysis, radiocarbon dating, historical sources and the context of discovery, it is argued that the assemblage may have been generated by 'resurrectionist' activities associated with the clandestine acquisition of cadavers for anatomical dissection.

INTRODUCTION

The history of anatomical dissection is dark and fascinating. The fourteenth and fifteenth centuries in Europe were a pivotal time in the history of medicine, most notably with the first official dissection of a human body taking place in Bologna in 1315.[1] Founded in 1495, the University of Aberdeen played a significant role in this continuing revolution and advancement of medicine as science, a fact clearly demonstrated by its being the first university in Britain to have a chair in medicine.[2] Human dissection in Aberdeen, however, did not officially take place until 1636, when two bodies were granted by the Privy Council for anatomisation at Kings College.[3] Over the coming decades, the demand for bodies to dissect in the anatomy schools quickly overtook supply, creating an opportunity for the rise of more clandestine activities; stealing of the bodies of the recently deceased. The historical perspectives on this practice are reasonably well explored.[4] However, it is only relatively recently that archaeological investigations have identified the tangible remains, legal and not so legal, of anatomist activities.[5] For instance, cut and scrape marks left by the surgeon's tools and preserved on the skeletal remains, illustrate specific procedures and interventions. This osteoarchaeological evidence is of significance as it is the only way to compare the theoretical approaches documented within the historical texts, to the realities of practice.[6] Yet, despite the influential positions and infamy of the Scottish anatomy schools and universities in Scotland at this time, they are underrepresented in the current literature. The aim of this paper is not simply to assess and interpret a sample of ostensibly anatomised human remains, but to explore the implications of the context of this material for our understanding of the realities of medical education in Scotland prior and subsequent to the Anatomy Act of 1832.

THE EXCAVATION

On the 13 November 2018, while digging the foundations for a private house extension in Aberdeen city, workmen uncovered fragmentary human bones and reported them to the police who in turn requested assistance from the local authority service. Following discussion with relevant experts the bones were recorded as archaeological. An excavation was

DOI 10.1080/00794236.2021.1972584

carried out on 23 November 2018 by Cameron Archaeology Ltd. This involved full excavation of the workmen's trench and the sieving of the soil comprising their spoil heap. Four discrete contexts were identified. Importantly, the presence of a lead pipe cutting through all contexts indicated a *terminus ante quem* in the early 19th century. In addition to the human remains, a small amount of pottery, faunal bone and building materials were also recovered.[7]

Human remains have not previously been recorded in this area. However, it is of note that close to the site, on the east side of King's Crescent, is the site of a former Leper Hospital (HER NJ90NW0016). The hospital is first mentioned in a charter of 1363 however, as leprosy is currently believed to have first come to Scotland following the Crusades in the 12th and 13th century,[8] it may well have been established earlier. By 1661 when Parson Gordon drew the first map of Aberdeen and wrote the accompanying, 'Description of Both Touns', he noted that the hospital was gone and few people remembered anything about it.[9] A watching brief in the area, although identifying a relatively small number of archaeological features, did not locate anything relating to the leper hospital.[10] The area where the human remains were found is now occupied by Canal Street, over which King's College had feudal superiority after the Reformation.[11] Canal Street was laid out from 1808 with housing plots appearing on the street over the next three decades. The historical and material evidence therefore indicates the house associated with the human remains was likely to have been built in the early to mid-19th century.

MATERIALS AND METHODS

All bone recovered from the excavation was assessed with four fragments identified as animal and the remaining 84 fragments identified as human. Estimation of sex and age-at-death was difficult due to the scarcity and highly fragmented nature of the remains. Nonetheless, where possible, sex was assessed using Walrath et al.'s method,[12] while age-at-death was estimated by way of dental eruption[13] and cranial development and thickness. When evaluating commingled and fragmented assemblages, such as that presented here, one of the most common methods for quantifying the assemblage is to calculate the Number of Identified Specimens (NISP)[14] and the Minimum Number of Individuals (MNI).[15] As the NISP assumes each recognisable fragment may represent an individual, it can produce a potentially inflated estimate of the number of discrete individuals forming the assemblage.[16] The MNI has previously been defined on the basis of the most common bone in the assemblage for non-adult[17] and adult individuals.[18] This provides the *minimum* estimate for the number of individuals that could have contributed to the sample.[19] When dealing with fragmentary remains, specific portions of an element (e.g. distal femur) may be used for the calculation. Every fragment must share a unique landmark to ensure that fragments of the same element of the same individual are not counted as two distinct individuals. The basic principle of an MNI estimate is to avoid counting the same individual twice.[20] A combination of this procedure and the NISP will provide a minimum (MNI) and maximum (NISP) number of individuals represented in a given assemblage. The remains were examined macroscopically with strong directional lighting to identify any features, damage or pathological lesions that may indicate their depositional history. Three samples, from three separate individuals, were sent for radiocarbon dating.

RESULTS

NUMBER OF IDENTIFIED SPECIMENS (NISP) AND MINIMUM NUMBER OF INDIVIDUALS (MNI)

The initial NISP was calculated to be 115, however, after refitting of fragments the NISP reduced to 84. Severe fragmentation, such as encountered with the Canal Street remains, can hamper the degree of identification accuracy and make it difficult to observe duplication.[21] However, in this case, the refitting exercise was very successful and has negated identification issues for many of the fragments.

Table 1 summarises all recovered elements and identifies those elements used to determine the MNI. The MNI for this assemblage is based on duplication of the area of the cranium referred to as Opisthion (the midline point at the posterior margin of the foramen magnum). A total of five instances of this portion of the cranium were identified (Fig. 1). Three of these individuals appeared to be adult, based on morphology and cranial bone thickness (Individuals 1, 2 and 5, Table 1). Two of the five are consistent with being non-adults (<10 years old) based on morphology and cranial bone thickness (Individuals 3 and 4, Table 1). Two additional sets of non-adult remains were identified by their frontal bones; however, these could not be confidently demonstrated to represent separate individuals from the two non-adults already contributing to the MNI of five (tentative Individuals '6?' and '7?', Table 1). Therefore, a conservative estimation of the MNI is five individuals (three adults and two non-adults), with a possibility that it could be as many as seven (three adults and four non-adults).

PATHOLOGICAL LESIONS AND TRAUMA

Given the highly fragmentary nature of the assemblage, very limited observations can be made

TABLE 1
Inventory of skeletal elements from Canal Street, Aberdeen with descriptions.

PE (Proximal epiphysis); P1/3 (proximal third of diaphysis); M1/3 (middle third of diaphysis); D1/3 (distal third of diaphysis) DE (distal epiphysis)
Completeness: 1= >75% present; 2= 25% – 75% present; 3 = < 25% present.
UN (unknown) ULB (unknown long bone)

Element	Individual	Side	Portion present	Completeness	Age	Sex	Notes on element presence	Additional description
Cranium	1	NA	occipital	1	Adult	UN	refit of 3/4 fragments.	**Sent for C14 dating** occipital portion, but fragmented - some of the fracture margins are new, others appear mineralised. Some porosity associated within the area of the nuchal lines. Large area of erosion to the ectocranial suture - diploe visible - approx 41 mm diameter.
Cranium	2	both		2	Adult	M?	6 refit fragments (including, frontal, left parietal, right parietal, occipital)	Strong nuchal lines (possibly Male). Clean, smooth margined cut surface in the transverse plane. Passes cleanly through lambda. Moves across the frontal in at an almost 30-degree angle (relative to transverse). Large, penetrating trauma to superior surface on the right parietal -trauma runs almost the entire length of the sagittal suture, from just posterior to the coronal suture, to just anterior to lambda - dimensions - 80.01 mm (max length) x 39 mm (max breadth). Clearly a more defined circular area - 39 mm x 50.32 mm. Fracture margins are white. Right parietal displays a straight linear feature running from lateral fracture edge at an angle towards the coronal suture - 25.61mm. Button/ivory

(*Continued*)

TABLE 1
(*Continued*).

PE (Proximal epiphysis); P1/3 (proximal third of diaphysis); M1/3 (middle third of diaphysis); D1/3 (distal third of diaphysis) DE (distal epiphysis)
Completeness: 1= >75% present; 2= 25% – 75% present; 3 = < 25% present.
UN (unknown) ULB (unknown long bone)

Element	Individual	Side	Portion present	Completeness	Age	Sex	Notes on element presence	Additional description
								osteoma (?) visible on the posteriolateral surface of the right parietal (15.20 mm x 10.22 mm). Further cutmarks (fine) visible on the anterior portion of the frontal as follows; on the left aspect, a cluster of cut/scratch marks perpendicular to the cut margin (6.0–6.5 mm), also a clear cut (12.47 mm) running at 70° angle to transverse margin. Similar depth of cut to right portion, (9.10 mm) located 12 mm superior of the transverse margin, at a 50° angle. Cut margin is consistent with a craniotomy.
Cranium	3	NA	occipital	1	Non-adult	UN	refit of 6 fragments. occipital portion.	Ossicles present along lambdoid suture (1 still present, 2nd one lost). Endocranially, porosity present in the region of the cruciform eminence.
Cranium	4	NA	occipital left parietal	2	Non-adult	UN	refit of 3 fragments.	ectocranial surface eroded - little of the cortical surface still intact. Either side of opisthion, medium sized holes - left posterior measures: 5.33 mm diam; damage to the right lacks the circularity of the other - more ragged and is open 13.82 mm x 9.03 mm.

(*Continued*)

TABLE 1
(*Continued*).

PE (Proximal epiphysis); P1/3 (proximal third of diaphysis); M1/3 (middle third of diaphysis); D1/3 (distal third of diaphysis) DE (distal epiphysis)
Completeness: 1= >75% present; 2= 25% – 75% present; 3 = < 25% present.
UN (unknown) ULB (unknown long bone)

Element	Individual	Side	Portion present	Completeness	Age	Sex	Notes on element presence	Additional description
Cranium	5	NA	occipital	1	Adult	UN	small portion of occipital incorporating opisthion	**Sent for C14 dating**
Cranium	6?	NA	frontal; right parietal	2	Non-adult 6-12 years	UN	refit of 7 fragments -	**Sent for C14 dating** frontal bone has clear penetrating injury. 'Doughnut' shape in appearance - (see images) positioned immediately over the glabella - max measurement of larger circle: 31.20 mm (superior/inferior) 28.32 mm transverse. An excised area of 6.16 mm in width surrounding an 'island' of circular bone which itself contains a small circular cut out of bone measuring 4.04 mm. max depth is 4.11 mm closest to nasion - reducing superiorly to 0.5 mm at its superior extent. Numerous fine striations around the superior external limit of the damage. The island of bone has many (over 6) linear striations - consistent with numerous cuts with a fine blade – varying depths. Some longer striations travel horizontally beyond the limit of the damage - they are not apparent within the defect. No signs of head trauma. Left orbit does display porosity - cribra orbitalia? Approximate age based on morphology (size and cranial thickness).

(*Continued*)

TABLE 1
(*Continued*).

PE (Proximal epiphysis); P1/3 (proximal third of diaphysis); M1/3 (middle third of diaphysis); D1/3 (distal third of diaphysis) DE (distal epiphysis)
Completeness: 1= >75% present; 2= 25% – 75% present; 3 = < 25% present.
UN (unknown) ULB (unknown long bone)

Element	Individual	Side	Portion present	Completeness	Age	Sex	Notes on element presence	Additional description
Cranium	7?	NA	frontal	1	Non-adult 6-12 years	UN	refit of 2 fragments -	Ectocranial surface - cortical bone delaminating. Approximate age based on morphology (size and cranial thickness).
Cranium	A	Right	temporal	1	Adult	M?	pathology - mastoiditis - see notes	Right mastoid and squamous portion approx. 13 perforations concentrated around the mastoid – mastoiditis? Largest diameter 7.48 mm Deepest approx. 6.8 mm Margins are smooth and sharp.
Humerus		Right	complete	1	Adult	UN		
Prox Hand Phalanx		UN	complete	1	Adult	UN		
Prox Hand Phalanx		UN	P1/3; M1/3	1	Adult	UN		
MC3		Left	P1/3; M1/3	1	Adult	UN		
Mandible		Both		2	Adult	UN	RI1, RI2, RC, PM1, PM2, (Lost PM), RM1, RM2, LI1 (Lost AM)	4 refit fragments (including coronoid process, mandibular condyle, right corpus). Molars lost AM, remaining anterior teeth lost PM. Area where M1 and M2 would have been still in the process of healing - potentially some light grey coloured reactive bone just anterior surface of the corpus, next to the alveolar margin of PM1 and extending to where M1 would have been. mental spines quite prominent.

(*Continued*)

TABLE 1
(*Continued*).

PE (Proximal epiphysis); P1/3 (proximal third of diaphysis); M1/3 (middle third of diaphysis); D1/3 (distal third of diaphysis) DE (distal epiphysis)
Completeness: 1= >75% present; 2= 25% – 75% present; 3 = < 25% present.
UN (unknown) ULB (unknown long bone)

Element	Individual	Side	Portion present	Completeness	Age	Sex	Notes on element presence	Additional description
Mandible		Left		3	Adult	UN	1 fragment, coronoid process and mandibular condyle	
Femur		Right	P1/3; M1/3	2	Adult?	UN	5 refit fragments	'chop mark' type feature to the linea aspera (4.80 mm length). Consistent with post-mortem damage (white margins).
Mandible		both		2	Non-adult	UN	1 fragment mandible LM_1 (in situ) -RI_2 alveolus	LC, LPM_1 visible within crypt. Age based on dental eruption – approximately 6-10 years.
Cranium		both	parietal	2	Adult	UN		
Femur		Right	PE	1	Adult	UN	femoral head and portion of the neck.	Pathology present - small area of new bone formation to the femoral head - irregular shape, 8.51 mm x 4.83 mm and raised 1.11 mm above the surface.
Femur		Right	PE	1	Adult	UN	greater trochanter - probably fits with femoral head, but unable to refit	
Tibia		UN	M1/3	1	Adult	UN	fragment of tibia - 2 refit frags	
ULB		UN	M1/3	1	Adult	UN	refit of 3 fragments - non diagnostic splinter	
Ulna		Right	PE	1	Adult	UN		New fracture
Ulna		UN	M1/3	1	Adult	UN		New fracture
Tibia?		UN	D1/3	1	Adult	UN		New fracture
Cranium		Right	parietal	1	Adult	UN	highly eroded - probably part of #8 (3 fragments refit)	

(*Continued*)

TABLE 1
(*Continued*).

PE (Proximal epiphysis); P1/3 (proximal third of diaphysis); M1/3 (middle third of diaphysis); D1/3 (distal third of diaphysis) DE (distal epiphysis)
Completeness: 1= >75% present; 2= 25% – 75% present; 3 = < 25% present.
UN (unknown) ULB (unknown long bone)

Element	Individual	Side	Portion present	Completeness	Age	Sex	Notes on element presence	Additional description
Cranium		UN	parietal				new fracture margins	
Cranium		left	parietal	1	UN	UN	refit 4 fragments - new breaks	
Cranium		left	parietal	1	UN	UN	probably belongs with above fragment - cannot refit - new breaks	
Cranium		left?	parietal	1	UN	UN	probably belongs with above fragment - cannot refit - new breaks	
Cranium		NA	occipital	1	UN	UN	fragment - fresh breaks	
Cranium		UN	parietal	1	UN	UN	fragment - fresh breaks	
Cranium		UN	UN	1	UN	UN	fragment - fresh breaks	
Mandible		Right	portion around the mental foramen	1	adult	UN	fragment - fresh breaks	
Cranial fragments							7 cranial fragments - various	
Cranium		NA	occipital	1	juvenile	UN	basilar portion - new breaks	
Faunal remains							4 fragments	Various portions of animal bone.
UN fragments							37	Numerous undiagnostic fragments of bone under 10 mm diameter.

FIG. 1
Minimum Number of Individuals demonstrated with 5 repeating cranial fragments (opisthion of the foramen magnum - arrowed).

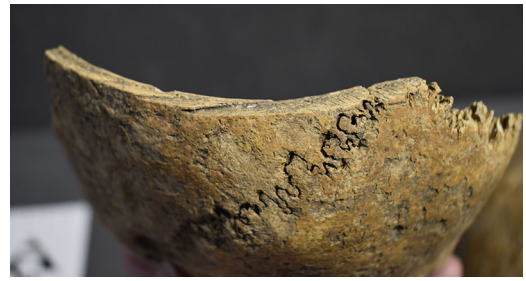

FIG. 2
Individual 2, detail of craniotomy viewed from the posterior aspect. Note the kerf marks along the smooth margin.

regarding disease. However, two of the specimens did display evidence of pathological change, and a further two specimens had clearly sustained perimortem damage. Table 1 summarises evidence for pathology with a brief precis provided below.

Possible evidence for mastoiditis was noted in a right temporal fragment (Cranium A in Table 1), probably from an adult male. Approximately 13 'perforations' are concentrated around the mastoid; the margins are indicative of remodeling. Mastoiditis is a disease that arises in connection with Otitis media (infection of the ear) and is defined by Flohr & Schultz as,[22] 'a chronic disease of the mucous membrane of the mastoid air cell system that also affects the bone substance underneath'.

Individual 2 was composed of 6 refitted cranial fragments (including frontal, left parietal, right parietal and occipital). The morphology is consistent with a biologically adult individual. A large, ovoid, penetrating injury to the superior surface was observed on the right parietal. This trauma runs almost the entire length of the sagittal suture, from just posterior to the coronal suture, to just anterior to lambda - dimensions - 80.01 mm (max length) x 39 mm (max breadth). However, the fracture margins are white, suggesting this is recent damage, most likely caused during discovery. The right parietal also displays a straight linear feature (probably a cut mark) running from the lateral fracture edge at an angle towards the coronal suture - 25.61mm. Another major feature of Individual 2 was a clean, smooth-margined cut surface in the axial plane, passing through lambda, travelling to the frontal at an almost 30-degree angle (relative to transverse plane). Kerf patterns (striations within saw tool marks) could also be identified along the margins (Fig. 2). At least two, further cutmarks (fine but quite deep), oriented perpendicular to the transverse plane, were clearly visible on the frontal portion (see Table 1).

Individual 6 was composed of 7 refitted fragments. The morphology is consistent with a child

FIG. 3
Individual 6, frontal aspect with dough-nut shaped defect consistent with attempted trephination procedure.

(approximately 6–12 years old). Mild porosity was observed in the left orbital roof consistent with cribra orbitalia. Cribra orbitalia is often cited as an indicator of iron deficiency anaemia.[23] The frontal bone displays an unusual, but clear penetrating injury. 'Doughnut' shaped in appearance (Fig. 3), it is positioned immediately over glabella.[24] The maximum measurement of the outer circle is 31.20 mm (superior/inferior) and 28.32 mm transversely. An excised area of 6.16 mm in width surrounds an 'island' of circular bone, which itself contains a small circular cut-out of bone measuring 4.04 mm. The maximum depth of this 'doughnut' feature is 4.11 mm at the point closest to nasion.[25] This depth reduces to 0.5 mm at its superior extent. Numerous, fine striations are

TABLE 2
AMS results for crania from 3 individuals from Canal Street. '…' refers to cases where the calibrated radiocarbon date may extend beyond the limit of the calibration curve.

Sample	Lab code	C:N	$\delta^{13}C$	$\delta^{15}N$	Radiocarbon Age BP	Calibrated age (95% probability range cal AD)	Modelled age (95% probability range cal AD)
Boundary (Start)							1744 – 1806
C001 (adult)	GU51668 SUERC - 87388	3.4	−20.0	12.4	234 ± 30	1528 – 1546 (2.8%) 1634 – 1684 (47.8%) 1734 – 1804 (40.8%) 1929 – … (4.1%)	1746 – 1809
C002 (adult)	GU51669 SUERC – 87389	3.3	−20.1	12.0	173 ± 30	1659 – 1699 (17.9%) 1722 – 1815 (47.6%) 1834 – 1887 (10.6%) 1909 – … (19.4%)	1746 –1810
Boundary (adult/child)							1750 – 1782 (37.5%) 1790 – 1812 (57.9%)
C006 (child) (10)	GU52894 SUERC - 89915	3.4	−20.6	12.5	135 ± 24	1675 – 1744 (26.7%) 1750 – 1765 (4.3%) 1798 – 1942 (64.4%)	1754 – 1783 (37.7%) 1794 – 1815 (57.8%)
Boundary (End)							1759 – 1785 (38.0%) 1797 – 1818 (57.5%)

identified around the superior, external limit of the damage. The island of bone has many (over 6) linear striations (transverse) of varying depth, consistent with numerous cuts with a fine blade.[26] Some longer striations travel horizontally beyond the limit of the damage; they are not apparent within the defect and would therefore suggest this came prior to the circular action. No evidence of associated trauma or other pathological lesions are identified.

CHRONOLOGY

The location of a lead pipe trench identified during excavation[27] indicated a relative date of early to mid-19th century for the deposition of the recovered assemblage. Canal Street was laid out from 1808 with housing plots appearing on the street over the next three decades.

All AMS radiocarbon measurements were undertaken by the Scottish Universities Environmental Research Centre (SUERC) and are presented in Table 2. Detailed methods are given in Dunbar *et al.*[28] The C:N ratio suggests that collagen was well preserved.[29] Dates have been calibrated against IntCal20[30] in OxCal v. 4.4.[31] Calibrated dates within this period are imprecise because of a large plateau in the calibration curve. However, we have exploited some of the structure within this plateau in an attempt to increase the precision of the age estimate by modelling within OxCal. This program applies Bayesian statistical methods to combine all chronological data from a site, where Phases of activity containing the radiocarbon dates are placed between Boundaries within a Sequence.

Using the lead pipe as a *terminus ante quem*, the final Boundary was assigned a prior probability of dating between 1760 and 1860. We also assume that the individuals died within a few years of each other and were buried shortly after. The radiocarbon content of a bone reflects the radiocarbon content of the individual's diet as the bone formed, and will always predate the date of death. Cranial bones remodel relatively slowly,[32] and so the final modelled Boundary will not only predate death, but the bones of the two adults will predate the age of the child. The difference between the adult and child bones is likely to be small as life expectancy[33] in Scottish urban areas was 35.5 and 32.6 years for females and males respectively.[34]

In OxCal, the radiocarbon dates were placed in two Phases within a Sequence, and the entire period of bone formation was allowed to occur for 10 ± 5 years. The final Boundary spans cal AD 1760 – 1818 at 95% probability. As individual 6 died between 6 – 12 years of age, the model suggests that our individuals are likely to have died prior to 1830. However, this model is particularly sensitive to the assumption we make about the period of bone formation. When it is extended to 20 ± 10 years, the final Boundary

spans cal AD 1759 – 1829. It is also sensitive to the assumption that no marine food was consumed. Stable isotope analyses suggested these individuals primarily ate terrestrial foods. However, stable isotope analyses are relatively insensitive to marine food consumption, and small amounts of marine food may make these samples appear slightly old. This is a particular concern for the oldest date, SUERC-87388, which anchors the model in the late 18th or early 19th century.

DISCUSSION

From the osteological perspective, Individual 2 and Individual 6 have both sustained perimortem (at or around the time of death) damage that requires further interpretation. The nature and patterning of trauma observed on Individual 2 is diagnostic of the outcome of a circumferential craniotomy.[35] This procedure essentially involves the removal of the top portion of the skull in order to facilitate examination of the anatomy of the brain.

Craniotomy is not described as a surgical procedure in the 18th and 19th centuries,[36] but it is a feature of post-mortem investigation (autopsy). However, issues of equifinality[37] arise as a similar procedure would be applied in the case of dissections, i.e. within the medical schools. Indeed, one of the ways for instructors in 16th-century Europe to gain access to more bodies was to persuade relatives of the need for an autopsy, even if this wasn't warranted.[38] This further confounds the situation as clearly an individual sent for autopsy might subsequently become a subject for dissection and teaching.[39] Furthermore, surgery, autopsy and dissection generally involved the same medical instruments, further precluding the confident differentiation of these procedures based on tool marks.[40] Consideration of the pattern/distribution of tool marks/damage may offer more insight as autopsies tend to follow prescribed methods.[41] An excellent illustration of this comes from the discovery of an 18th-century burial ground that would have been associated with the Royal Infirmary in Edinburgh.[42] Skeletal remains of six individuals and additional disarticulated bone were recovered from the site. The distribution of cut marks, scrape marks and a craniotomy were demonstrated as consistent with the historical accounts of autopsy methods; the disarticulated remains consistent with amputation.[43] The context of the Edinburgh discovery, within a hospital burial ground, adds certainty to the conclusions drawn by Henderson *et al*. that the individuals had been subject to postmortem investigation. Moreover, while dissection was not permitted, it is entirely possible the autopsies of the Edinburgh individuals could have provided excellent case studies for medical students. It is of note that in the case of the Edinburgh remains, the skeletons and disarticulated bones were all located within a designated burial ground (and their treatment appears to be in keeping with the law around autopsy and clinical waste). It is not possible to differentiate between dissection and autopsy in the instance of Individual 2 as we are dealing with individual fragments, rather than whole skeletons.

The doughnut-shaped feature on the frontal portion of Individual 6 is consistent with the application of a tool moving in a circular motion, such as would be seen in a manual trephination procedure. Trephination, described as the surgical removal of a piece of skull "to create a communication between the cranial cavity and the environment,"[44] is not only well-documented historically, but also represents the oldest known form of surgical intervention.[45] The evidence suggests events that involved first the cutting away of skin over the frontal region (indicated by the cut marks) to expose the bone surface,[46] before attempting trephination, which was clearly incomplete. It was felt the damage was consistent with a 'crown trepan'. A trepan kit is held within the collections at Marischal College Museums and it was therefore possible to apply the crown trepan from this set to the damage on this cranium. It was found to be a perfect fit. However, despite presenting clear evidence for medical procedures, caution is needed in understanding why an individual might have been subjected to either of these actions.

The dramatic looking trephination marks on the frontal of Individual 6 creates uncertainty as to the nature of their origin, i.e. surgery or surgical training/practice. The lack of any pathological response indicates the, minimally, perimortem application of a trephine (trephination tool). Trephination was carried out in cases of; depressed fractures, symptoms indicating disturbance of the brain, inflammation and putrefaction (of the dura), in addition to epidural haematoma, often due to accident or assault or infection.[47] Lack of osteological evidence, either pathological or traumatic, that might indicate the need for such an intervention is also absent. The cuts may be characterised as deep and numerous, arguably attesting to a trainee learning to carry out the procedure - further suggesting the individual was already deceased. Practice of medical procedures on cadavers occurred in the anatomy schools of the 19th century, including multiple trephinations as evidenced at the Craven Street site in London[48] and serial amputations of the same limb at different heights.[49]

The discovery in Belfast[50] of a late 18th or early 19th century isolated cranium with multiple trephination attempts, in an area where it is documented that several physicians lived, provides a striking comparative example to the case detailed here. The holes in the Belfast individual are situated on the more superior aspects of the cranium (frontal and parietal) and the authors believe this indicates the cranium was placed on a table during this activity.[51] Following

this logic, we may therefore infer that the Aberdeen individual presented here may have been arranged in anatomical (extended, supine) position, which is arguably a further indication of the use of an intact body. As with the Belfast example, Individual 6 also presents an incomplete attempt at the procedure. It therefore seems likely that the trauma to this cranium was the result of an attempt to 'practice' the surgical procedure of trephination on an already deceased individual. Finally, this cranial specimen is that of a child. The bodies of children were not excluded from dissection, although their corpses fetched less money due their small size[52] as they could accommodate fewer students. Indeed, Hurren[53] notes just 1% of the bodies (n= 5062) officially sold to St Bartholomew's Hospital between 1832-1929, were under the age of 10. The use of a child in this case may infer a cadaver supply issue around this time. Importantly, historical evidence for the role of children's cadavers in the history of medical education is rare; the osteo-archaeological evidence is even more elusive.

The relative date of early to mid-19th century as indicated by the historical records and lead piping, and given further resolution through the scientific dates (Table 2), clearly situates this small assemblage against the backdrop of the Enlightenment; a time of great scientific discovery and controversy, particularly in the pursuit of medical knowledge and learning. In Scotland, this period is more immediately associated with the private anatomy schools of Edinburgh due, in no small part, to the infamous activities of the so-called resurrectionists, most notably Burke and Hare.[54] However, Aberdeen possesses an equally rich and fascinating history.

In 1636, the Privy Council granted permission for human anatomy to be taught at Kings College, Aberdeen, by ordering the bodies of either two criminals or 'bodies of the poor' to be made available.[55] Nationally, acquisition of subjects for study was notoriously difficult, an issue that was creatively exploited with the development of the Murder Act of 1752. This Act directed the bodies of executed criminals to be transferred to the surgeons for public dissection whilst simultaneously facilitating a supply of cadavers to the anatomy schools.[56] This casting of dissection as a level of horror and punishment beyond even death itself[57] no doubt did little to alleviate the sense of fear and mistrust that was gathering around the anatomy schools like a miasmic menace. Attempts to evade the surgeon's knife ranged from skirmishes at the scaffold between relatives and anatomists, bodies entrusted to sailors for burial at sea, and even the pouring of vitriol (sulphuric acid) on the body in order to render it useless to the surgeons.[58]

However, despite the new ruling, the supply of bodies could not keep up with demand.[59] Theft of corpses shortly after burial, often by medical students,[60] became an infamous issue. Moreover, while the clandestine activities of these 'resurrectionists' served to further alienate the medical schools from the public, it also serves to demonstrate the passionate pursuit of knowledge at this time. There are many accounts of these activities. Specifically, within Aberdeen, the Aberdeen Medico-Chirurgical Society, formed by medical students in 1789, is known to have actively encouraged the sourcing of cadavers from the graveyard.[61] In particular, the graveyards of Spital and St Machar proved popular hunting grounds, with documented prosecutions in 1815 and 1827 of Aberdeen medical students for resurrectionist activities.[62] Archaeologically speaking, the most telling physical evidence may be recognized in the development of the mort safes, also known as anti-resurrectionist devices.[63]

Public anxiety over dissection and the sourcing of corpses increased with the case of Burke and Hare in 1828 and the 'London Burkers' in 1831, crescendoing with the Aberdeen Anatomy Riot of December 1831, which saw a mob attack Moir's anatomy school and burn it to the ground.[64] This was the final catalyst for the passing of the Warburton Anatomy Act of 1832. This new law changed the source of cadavers for medical teaching and research from executed criminals, to those of the poor and unclaimed. This move had repercussions not only for the practice of medical education, but perhaps more significantly, on the treatment of the poor and destitute.[65] During the period from 1842–1902, official records demonstrate that the bodies of 1479 persons were sent to the Aberdeen medical schools for dissection.[66] Could the assemblage presented here have a connection with this period in the history of medicine? It has been noted that one of the outcomes of medical dissection is the disaggregation of the body.[67] Although we cannot reference the fragmentary nature of this assemblage as diagnostic of dissection in itself, taken in consideration with the osteological indicators for anatomically driven procedures described above, an involvement with the 19th century anatomists is compelling.

The context of discovery is of further significance. Currently, evidence of a cemetery in the immediate environs of the site is lacking. The lands now forming Canal Street were originally two crofts, Humphrey's Croft and Sickhouse Croft (noted in the King's College feus); the sick house croft logically refers to the much earlier Leper hospital northeast of the find site. It is possible that the remains were accidentally brought in with soil used to level up the garden in Canal Street as part of the original foundation works; certainly the digging of the original canal in the late 18th century and then the railway in the mid-19th century would have resulted in soil movement.[68] Following the Anatomy Act of 1832, medical schools had a legal responsibility to bury the remains within designated spaces in the city; St Nicholas Kirkyard at Schoolhill, St Clement's Kirkyard at Footdee and Nellfield Cemetery near Holborn St.[69] The discovery

of a disarticulated skull with a craniotomy during excavations at St Nicholas Kirkyard[70] may well have come from the medical schools. Bodies (or indeed parts), may also be returned to the cemeteries associated with workhouses and pauper hospital burial grounds.[71] Given the designation of specific areas for the deposition of such remains following the 1832 Act, it seems unlikely such remains could have been accidentally incorporated from any of these locations. Beyond this, it is known that many anatomists had private collections, and it cannot be entirely dismissed that these remains may have come from a more clandestine deposition of cadavers obtained through improper channels. Investigation of the historical Census records revealed that in 1851, the associated house had student lodgers at least one of whom, Alexander Creyk, was a student at Kings College Aberdeen. Furthermore, Mr Creyk's father was a surgeon in Elgin.[72] While it is not possible to state that Alexander Creyk studied anatomy, his brother William did and subsequently became Surgeon-Lieutenant-Colonel in the Army Medical Staff, being registered from 14th April 1863 until retirement in May 1888.[73] Could this add up to a student of anatomy disposing of incriminating evidence of the illegal acquisition of cadavers? Given the illegality and clandestine nature of the acquisition of bodies for dissection, there is little information around methods of disposal. Examples discovered tend to be within formal burial grounds.[74]

The common understanding within the literature is that after 1832, the shortage of bodies for dissection abated and as a result, the practice of grave robbing faded out. However, closer reading may indicate that this was not necessarily the case.[75] Although anatomical institutions in Glasgow and Edinburgh reported the supply of bodies to be excellent, this was not the experience in Aberdeen. According to Hoole's[76] research, of the 250 bodies a year documented as being anatomised in Scotland, just twenty to thirty bodies annually were dissected at Aberdeen. An account by F.J. Shepherd[77] on a tour from Canada of anatomy schools in Britain, refers to the many students he encountered in Aberdeen and the fantastic facilities, stating how carefully and thoroughly anatomy was being taught during the time of Dr Struthers. Given the official paucity of bodies being donated via official channels, the likelihood of resurrectionist activities still ongoing seems plausible. Ritchie[78] recounts the incident of a mort safe discovered during grave digging at Banchory Devenick, which had been placed over the coffin of a man interred in 1854. The father of this individual was a watcher in the Parish Churchyard (to guard against the theft of bodies) and clearly felt that even 20 years after the passing of the Anatomy Act, it was still necessary to guard against the activities of Resurrectionists. With this in mind, the likelihood that this assemblage was derived from the illegal acquisition of bodies, cannot be dismissed.

CONCLUSIONS

Although the Enlightenment is known as a period of fast-paced scientific discovery, for others is was an era of 'social unrest, suspicion, mistrust, disease and destitution.'[79] The Anatomy Act of 1832 placed power and control over the bodies of the socially disadvantaged in the hands of state sanctioned authorities. The possibility of an individual's body being sent to the anatomy schools for dissection was a very real fear for the lower social strata of society.[80] It is against this backdrop of contrasting perceptions; advancing medical knowledge on one hand, and fear over the fate of the corpse on the other, that the small human bone assemblage excavated in Aberdeen city is situated. The evidence generated from osteological analysis, radiocarbon dating, historical sources and consideration of the context of recovery, has thrown light on a fascinating period in history, and generated a complex conundrum. It is argued the assemblage was generated by activities associated with anatomical dissection in the late 18th – early 19th centuries. It has not been possible to say with certainty if these remains pre-date or post-date the watershed moment of 1832, potentially speaking to their legality. However, it has been argued that the passing of the Anatomy Act did not create an absolute cessation of clandestine activities,[81] with resurrectionist misdeeds rumbling on in some areas for several decades. The context of discovery, clearly outside any spaces designated for official burial of individuals sent to the dissecting rooms, lends considerable weight to the conclusion that this assemblage is the first archaeological evidence for the less salubrious side of the 19th century Scottish anatomy schools.

ACKNOWLEDGEMENTS

We would like to thank Police Scotland and Detective Sergeant Stephen Beattie for their initial response to the discovery, and to Jamie Grieve, Margaret Bruce and Leighanne Deboys for their assistance and expert advice in identifying the skeletal remains. Thanks to the owners of the property who allowed access. Aberdeenshire Council Archaeology Service kindly facilitated and funded the work.

NOTES

[1] Ghosh 2015, 155
[2] Humphries 2014, 67
[3] Bennett 2018, 160

[4] Mitchell 1949; Richardson 2000
[5] see discussions by Dittmar & Mitchell 2015, 2019; Mitchell 2012; Western 2015
[6] Mitchell 2012, 6
[7] Cameron *et al*. 2019
[8] see discussions in MacLellan 2017; Roberts 2002
[9] Aberdeen HER online; Cameron 1990, 17
[10] Aberdeen HER online; Jones and Mitchell 2008, 12; Mitchell and Jones 2007, 9
[11] Morgan 1995, 65
[12] Walrath *et al*. 2004
[13] Al Qahtani *et al*. 2010
[14] Lyman 2001, 100
[15] Knüsel & Outram 2004, 86
[16] Klein & Cruz-Uribe 1984
[17] For the purposes of this paper, non-adult refers to a biological age of 12 years or less
[18] Bökönyi 1970
[19] Lyman 2001, 100
[20] Adams & Konigsberg 2004, 139
[21] Crozier 2016; Lyman 2001, 103
[22] Flohr & Schultz 2009, 100
[23] see McFadden & Oxenham 2020
[24] Glabella is the anatomical landmark between the brow ridges
[25] Nasion is the anatomical landmark at the bridge of the nose
[26] see Greenfield 1999
[27] Cameron 2018
[28] Dunbar *et al.* 2016
[29] van Klinken 1999
[30] Reimer *et al.* 2020
[31] Ramsey 2009
[32] Clarke 2008, Fahy *et al*. 2017, McFadden and Oxenham 2020
[33] This refers to life expectancy at birth for this time period in Scotland. It does not mean the dated individual(s) necessarily only survived to this age.
[34] Torres *et al.* 2019
[35] Dittmar & Mitchell 2015, 74
[36] Dittmar & Mitchell 2015, 74
[37] see Lyman 2004
[38] Ghosh 2015
[39] Dittmar & Mitchell 2015
[40] Dittmar & Mitchell 2015, 74; Dittmar & Mitchell 2019
[41] Dittmar & Mitchell 2015, 74; Dittmar & Mitchell 2019
[42] Henderson *et al.*1996
[43] Henderson *et al.*1996
[44] Aufderheide & Rodríguez Martin 1998, 31
[45] Arnott *et al.* 2005
[46] Reflection of the skin prior to trephination is a standard procedure (Ortner 2003, 172). An historical case-study by Newton (1907) describes surgery to trephine a child's skull, whereby the skin was carefully cut and reflected back to facilitate clean suturing of the wound after trephination was completed.
[47] Ganz 2014
[48] Hillson *et al.* 1998, 16
[49] Mitchell *et al.* 2011, 95; Chamberlain 2012, 18
[50] Ó Baoil *et al.* 2002, 7
[51] Ó Baoil et al. 2002, 7
[52] Mitchell *et al.* 2011
[53] see Hurren 2012, 164 Figure 4.5
[54] Humphries 2014, 67
[55] Humphries 2014; Bennett 2017, 160
[56] Ghosh 2015, 65
[57] Bennett 2017, 160
[58] Bennett 2017, 161–162
[59] Hildebrandt 2008
[60] Mitchell 1949, 419–420
[61] Humphries 2014, 69
[62] Hoole 2018, 238
[63] Ritchie 1911; Humphries 2014
[64] see Hoole 2018
[65] Bennett 2017; Richardson 2000
[66] Hoole 2018, 251
[67] Dittmar & Mitchell 2019, 285
[68] Cameron 2018
[69] Hoole 2018, 249
[70] Duffy *et al.* 2008, 173
[71] Mitchell *et al*. 2011, 92
[72] 1844 Russell's Morayshire Register, and Elgin and Forres Directory
[73] Anderson 1893
[74] e.g. Henderson *et al.*1996; Chamberlain 2012
[75] Ghosh 2015, 66
[76] Hoole 2018, 253
[77] Shepherd 1887, 3
[78] Ritchie 1911, 310
[79] Hoole 2018, 240
[80] Hoole, 2018; Mitchell *et al.* 2011
[81] Richardson 2000

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SUMMARY IN FRENCH, GERMAN, ITALIAN AND SPANISH

RÉSUMÉ

Preuve ostéoarchéologique d'une dissection médicale aux XVIIIe-XIXe siècles, à Aberdeen, Ecosse

Cet article décrit l'analyse d'un petit assemblage de restes humains fragmentaires découverts au cours de travaux de rénovation dans une propriété résidentielle de la ville d'Aberdeen, en Ecosse. Deux lots de restes crâniens présentent des traces évidentes d'activités d'autopsie ou de dissection: une craniotomie et une trépanation. La datation radiocarbone les situe à la fin du XVIIIe- début du XIXe siècles, probablement contemporain de l'adoption de l'*Anatomy Act* de 1832. On peut déduire, de l'ensemble des données issues des analyses ostéologiques, du radiocarbone, des sources historiques et du contexte de la découverte, que l'assemblage provient d'activités « résurrectionistes », liées à l'acquisition clandestine de cadavres à des fins de dissection anatomique.

ZUSAMMENFASSUNG

Osteoarchäologische Nachweise für medizinische Autopsien im 18. und 19. Jahrhundert in Aberdeen, Schottland.

Im Artikel wird die Analyse einer kleinen Assemblage menschlicher Überreste beschrieben, die im Rahmen von Renovierungsarbeiten in einem Wohngebäude in Aberdeen, Schottland, entdeckt wurden. An zwei unterschiedlichen Schädelüberresten konnten dabei Hinweise für Autopsien festgestellt werden, namentlich eine Kraniotomie und eine Trepanation. Durch eine Radiokarbon- Datierung können die Überreste in das späte 18. und frühe 19. Jahrhundert datiert werden, und fallen somit in die Zeit der Verabschiedung des „Anatomy Act "von 1832.

Durch die Zusammenführung der osteoarchäologischen Analyse, der Radiokarbon-Datierung, historischer Quellen und dem Kontext der Fundstelle wird argumentiert, dass die menschlichen Überreste mit „Auferstehungs"-Aktivitäten und dem heimlichen Erwerb von Leichen in Verbindung gebracht werden können.

RIASSUNTO

Dati osteoarcheologici sulla dissezione medica fra XVIII e XIX secolo ad Aberdeen, Scozia

Questo lavoro descrive l'analisi di un piccolo deposito di resti umani frammentari, scoperto durante la ristrutturazione di una proprietà residenziale nella città di Aberdeen, in Scozia. Due serie di resti di crani mostrano chiari segni di attività di dissezione/autopsia: una craniotomia e una trapanazione. La datazione al radiocarbonio li colloca fra il tardo XVIII e l'inizio del XIX secolo, probabilmente in concomitanza con l'approvazione dell'*Anatomy Act* del 1832. Considerando congiuntamente i dati dell'analisi osteologica, la datazione al radiocarbonio, le fonti storiche, e il contesto di rinvenimento, viene suggerito che il deposito sia il risultato delle attività di 'trafugatori di cadaveri' in relazione all'acquisizione di corpi per le dissezioni anatomiche.

RESUMEN

Evidencia osteoarqueológica de disección médica de los siglos XVIII al XIX en Aberdeen, Escocia

Este artículo describe el análisis de un pequeño conjunto de restos humanos descubiertos durante renovaciones en una propiedad particular en la ciudad de Aberdeen, Escocia. Se trata de dos conjuntos de restos craneales con una craneotomía y una trepanación, evidencias claras de haber sido sometidos a una disección o autopsia. La datación por radiocarbono los ubica a finales del siglo XVIII y principios del XIX, y son seguramente contemporáneos con la fecha en la que se aprobó la Ley de Anatomía de 1832. Tras el análisis osteológico, la datación por radiocarbono, el estudio de las fuentes históricas y por el contexto del descubrimiento, sugerimos que el conjunto fue generado por las actividades 'resurreccionistas' asociadas con la adquisición clandestina de cadáveres para la disección anatómica.

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