**Bilateral proximal radio-ulnar synostosis: an archaeological case study from Virton (Belgium)**

by HÉLÈNE DÉOM

Bilateral proximal radio-ulnar synostosis is a rare anomaly, which is relatively well-documented clinically but less known in palaeopathology. Osteological analysis revealed this condition in a young adult from a 13th to 18th century parish cemetery in Virton (Province of Luxembourg, Belgium). It is the first archaeological case to be reported from Belgium. Analysis of the remains permitted detailed description of this condition, despite fragmentation of the material. Eburnation on the proximal left radius and right ulna indicate wear to the elbow joint's cartilage. Atrophic humeri and clavicle were also recorded. Differential diagnosis considered both congenital and traumatic aetiologies. Comparisons were made with reported case studies of fused forearms from archaeological contexts. The extent of the fusion and radiographical observation of the bones suggest connection of the medullary cavities. The congenital occurrence was favoured: probably a congenital anterior dislocation of the radii and ulnae. The main biomechanical implications are that normal pronation and supination was impossible for this individual, and that at least his left elbow was most likely stuck in a flexed position.

Keywords: osseous fusion; congenital dislocation; forearm; shoulder; biomechanical implications; secondary osteoarthritis

**Introduction**

Virton, situated in the Province of Luxembourg in Belgium (fig. 1), is historically interesting for its ancient heritage. In autumn 2012, a rescue excavation was conducted at the town’s Grand Place by archaeologist Denis Henrotay and his team from the Public Service of Wallonia (SPW) to record any important historical and archaeological remains before the area was renovated (Henrotay 2014). Archaeological excavations revealed traces of a primitive church and its cemetery dating back to the 13th century (Henrotay 2014). The cemetery was in use until the 19th century, after which it was moved to another area, while the ancient church was demolished (Roger 1932: 550-572). This historical relocation included transferring most of the human remains to the new consecrated ground. However, some skeletons were forgotten and left in situ at the Grand Place. Modern installations of electric cables and water pipes also disturbed the site in the 21st century (Henrotay 2014).

All remaining burials were excavated from October to December 2012, revealing about 70 skeletons (62 adults and 6 immature individuals). Due to the numerous disturbances, the general state of preservation of these remains is quite fragmentary.

One skeleton from stratigraphic unit 48 in the burial VIR12 01.048 F54, also known as ‘Individual 48’, presented a rare skeletal anomaly. Macroscopic observation and radiographical analysis show a bilateral proximal radio-ulnar synostosis. After consulting published material and conferring with renowned Belgian archaeo-anthropologists, it is clear that this is the first historical case reported from Belgium. This case study aims to provide further information regarding the rare pathological condition observed in this context and reflect on the physical (dis)ability of this individual.

**Individual 48**

Skeleton 48 was buried individually in a supine position (fig. 2). Due to poor preservation, no grave inclusions were available to give this burial a more precise date. Therefore, it is listed as ranging from the 13th to 18th century, which is when the cemetery as a whole was in use (Henrotay, pers. comm.). Individual 48 was buried without a coffin, forearms flexed and hands on
Figure 1 Location of Virton, Province of Luxembourg, Belgium (image from H. Déom: 2015).

the abdomen. This burial practice is typical of other late medieval graves, but little information is available regarding the rest of the community, as the remains were relocated and repeatedly disturbed.

Skeleton 48 is incomplete (anatomical preservation index: 22 percent) due to taphonomic erosion, disturbance by later burials and their removal. It lacks the scapulae, the right clavicle, several ribs and vertebrae, the patellae, the fibulae and foot bones. Anatomical connection appears disrupted for the right arm. Every bone is moderately fragmented. Erosion of the general surface of the bones is moderate to severe. Damage to the pelvis and skull prevented accurate sex assessment. Age at death is based on the first lower molars (wear: 20-24 years old) and the medial epiphysis of the clavicle (fusion: 25-27). Overall age at death is therefore estimated to be around 25 years old (Brothwell 1981; White and Folkens 2005: 369). This young adult’s skeleton was affected by bilateral radio-ulnar synostosis, which lead to secondary osteoarthritis, porosity and eburnation in both elbow joints (Waldron 2008: 24-77). Pathological lesions were also present on the vertebrae and the dentition. Osteophytes were recorded around the apophysial facets of the vertebrae, indicating early signs of degeneration at the vertebral column. A carious lesion affected the lower right molar, on the mesio-vestibular aspect. Additionally, linear enamel hypoplasia was present on the upper right canine.

Figure 2 Burial fact 54, stratigraphic unit 48 in situ, Virton (image from Denis Henrotay (SPW-DGO4): 2012 [not published]; reproduced with permission of author).
Radio-ulnar synostosis: a detailed description

Individual 48’s osseous synostosis only occurred on the proximal aspect of the radius and ulna, and was observed bilaterally. The bones are fused in a non-neutral position and have not fully developed proximal epiphyses. The cortical bone is pitted and eroded.

The left synostosis (fig. 3) consists of the fusion of the radial tuberosity on the radial notch of the ulna and measures 2.8 cm. Small crests and holes are observed in the fusion between the heads. The radial epiphysis has a pointed projection and a distinct contour. Although eroded, the ulnar head presents abnormal crests and cortical discontinuities. The ulnar trochlear notch appears to have atrophied. Coupled with torsion of the proximal ulna, this indicates an anterior dislocation of the radial head. All these observations also suggest the left forearm was stuck in pronation.

On the right synostosis (fig. 4), the radial head is fused with the ulna below the coronoid process, and measures about 2 cm. The trochlear notch is small and relatively flat. The radial head is hypoplastic and the radial tuberosity is partly present. This position suggests that the radial head was anteriorly dislocated and that the right forearm was stuck in semi-pronation. The shafts demonstrate a difference in size between the radius and ulna: the radius seems relatively more robust than the ulna; no diaphyseal bowing can be observed due to fragmentation.

Figure 3a Left radio-ulnar synostosis (lateral view), skeleton 48 (image from H. Déom: 2015).

Figure 3b Left radio-ulnar synostosis (medial view), skeleton 48 (image from H. Déom: 2015).

Figure 4a Right radio-ulnar synostosis (lateral view), skeleton 48 (image from H. Déom: 2015).

Figure 4b Right radio-ulnar synostosis (medial view), skeleton 48 (image from H. Déom: 2015).
Radiography of both forearms (fig. 5) suggests fusion of the medullary cavities. Despite some slight radiolucency, possibly due to soil erosion (Mays & Pinhasi 2008: 81), a continuous line of compact bone connects the radius and the ulna, along with continuous trabecular bone as well.

**Differential diagnosis and comparative examples**

**Congenital radio-ulnar synostosis & congenital dislocation of the radial head**

Congenital radio-ulnar synostosis is a rare anomaly that can be observed in the foetus. It is medically detected between 2 and 5 years of age and also documented in older individuals. Fusion occurs proximally and bilaterally in 60 to 80 percent of the cases, depending on the type of synostosis. It can be isolated to the radio-ulnar joint or accompanied by other post-cranial anomalies such as syndactyly, osteo-chondro-syndactyly, hip dislocation, clubfoot, multiple exostoses, etc. (Auferheide and Rodríguez-Martin 1998: 73; Underdown 2010). The aetiology of this condition is not entirely understood but is suggested to be a genetic condition and/or the result of various developmental factors impacting on the foetus during the formation of the elbow and arm, especially between the 34th and 37th days of pregnancy (Auferheide and Rodríguez-Martin 1998: 73; Bennett 1924; Farzan et al. 2002; Siemianowicz et al. 2010; Underdown 2012).

Different types of congenital radio-ulnar synostosis are reported in the literature. The primary type is a true congenital occurrence. The fusion measures about 3 to 6 cm and it connects the medullary cavities (Antón and Polidoro 2000; Auferheide and Rodríguez-Martin 1998: 73; Wilkie 1914). It is bilateral in 80 percent of the cases and can consist of a fibrous or osseous union (Cleary and Omer 1985; Farzan et al. 2002). The radial head tends to present a domed appearance. The radial shaft is longer, thicker and bowed anteriorly, whereas the ulnar shaft is atrophied and the distal humerus remains normal (Antón and Polidoro 2000; Auferheide and Rodríguez-Martin 1998: 73). The primary type is caused by a defect before seven weeks in utero. This fusion results in a position where the forearm is permanently and partially flexed (Antón and Polidoro 2000; Auferheide and Rodríguez-Martin 1998: 73; Scheuer and Black 2010: 263-277).
The secondary type is a congenital dislocation of the radial head fusing at the coronoid process. This type of synostosis measures about 2 to 3 centimetres. Also rare, it is recognizable by the presence of defective epiphyses at the elbow joint. The radial head has a round and hypoplastic shape, with a central depression and overgrowth (Antón and Polidoro 2000; Auferheide and Rodríguez-Martin 1998: 73; Thompson 2001). The proximal ulna is concave and the shaft is also atrophied or bowed (Farzan et al. 2002; Thompson 2001). The distal humerus can present a small, grooved or even absent capitulum. Anterior or posterior dislocation of the radial head occurs after seven weeks in utero. It usually affects both forearms, resulting in semi- or total pronation and, occasionally, partially flexed limbs (Antón and Polidoro 2000).

To sum up, the differences between primary and secondary types of synostosis are the length of the fusion, its position and the bones’ appearance. Indeed, type 1 is recognized by a longer fusion, domed radial head and a normal humerus. Type 2 is identified by a fusion at the coronoid process, a round proximal radius with a central depression, a bowed ulna and defective humerus.

Identification of the type of congenital radioulnar synostosis is not always possible in the archaeological literature. Thirteen cases of congenitally fused forearms were recently recorded worldwide from prehistoric and historic contexts (Titelbaum and Verano 2013): four were reported in Europe, seven in North America and one in Peru. They are generally considered as type 1, mostly unilateral (seven cases), and pronated. One of them was flexed, similar to Individual 48’s left forearm. Four other cases (Antón and Polidoro 2000; Bennett 1924; Farzan et al. 2002; Siemianowicz et al. 2010) are bilateral, like Individual 48. The impact of congenital radioulnar synostosis on muscles and bones is sometimes described in the osteoarchaeological literature, but other biomechanical effects, such as degenerative joint diseases, are not reported. No comparative information was found concerning osteoarthritic occurrences as observed in Individual 48.

**Dislocation and (post-)trauma**

Proximal radio-ulnar synostosis can also be explained by trauma, despite the fact that traumatic injuries of the radii and ulnae are more likely to happen at midshaft (Evans 1949; Thompson 2001). Caused by a traumatic event to the mother, fusion may occur in utero, usually unilaterally (Antón and Polidoro 2000). Depending on the type and severity of trauma as well as the time of occurrence (in utero or post natum), changes to the bones are variable and challenging to identify.

Fractures at the elbow generally occur in both radius and ulna (Evans 1949; Lovell 1997; Nikitovic et al. 2012; Underdown 2012). A healed traumatic bilateral example from an archaeological case in Argentina was recently reported by Underdown (2012) and is explained with ethnographic evidence of fighting. Indeed, fist-fighting occasionally affected males’ elbows uni- or bi-laterally. Fractures of the proximal radius and ulna consistent with fist-fighting show signs of healing as well as synostosis, shortening, misalignment and bowing of the radius. Osteophytic build-up on the distal humerus is also characteristic of this type of trauma and the functionality of the forearms would be reduced (Underdown 2012).

Dislocations of the forearm usually happen at the radius while the ulna is fractured, or vice versa. This is known as the Monteggia pattern (Evans 1949; Lovell 1997). Bones affected by such dislocation fracture generally show signs of osteoarthritis as well as ossification of membrane, ligaments and tendons (Lovell 1997). Nikitovic et al. (2012) found an example of this on an Eneolithic child at Josipovac-Gravinjak (Croatia) exhibiting a unilateral short radio-ulnar synostosis. The child suffered from an unreduced dislocation as indicated by porosity and periostitis on the radius, exostosis on the ulna and incipient synostosis (Fowles et al. 1984; Thompson 2001). No data on long-term impact is available. Nevertheless, epiphyseal atrophy may happen due to shortening of soft tissues while healing (Thompson 2001).

As discussed, traumatic events usually produce characteristic evidence, such as remodelling, which is not found in Skeleton 48. However, long-term healing may have masked any trace other than fusion, atrophy and osteoarthritis (Lovell 1997). The pathological observations on Individual 48 cannot be confidently assigned to trauma because there are other causes of epiphyseal atrophy and osteoarthritis. Moreover, it is unlikely that the extent of the fusion, the connection of the medullary cavities, the malformation of the radii and ulnae and the defect observed at the
clavicle (see below) can be explained by trauma.

When comparing the appearance of Individual 48’s radio-ulnar synostosis to archaeological and clinical data, it is likely to be of congenital aetiology. The trabecular bone observed in the radiographs appears to be continuous between the radius and ulna on both the right and left sides. This implies that fusion might have occurred during foetal development. The position of the bones, the malformed appearance of the epiphyses and the fact that the fusions measure 2 to 3 cm suggest a congenital dislocation (type 2). However, the diaphyseal bowing expected in dislocations is not visible on the fragmentary nature of the bones (Farzan et al. 2002; Thompson 2001). Thus, taphonomic damage limits the diagnosis.

Biomechanical implications

Although rarely mentioned, congenital and traumatic osseous radio-ulnar synostoses would have biomechanical implications (Antón and Polidoro 2000). For example, osteoarthritis and/or degenerative joint diseases associated with this condition would have caused damage and pain in the joints, limiting movements to a certain extent. In addition, normal pronation and supination are impossible with such a condition in an adult (Aufderheide and Rodriguez-Martin 1998: 73; Scheuer and Black 2010: 277).

Muscle attachments on the proximal parts of the bones indicate that the condition impacted the soft tissues as well as the biomechanical function of the forearms. Indeed, since the bones are fused together, all muscles that have a role in pronation or supination were affected to a certain degree (Antón and Polidoro 2000; Gosling et al. 2008). The distal shafts seem to be relatively normal, but the Lister’s tubercles (i.e. the prominence in the middle of the posterior distal radius) appear somewhat increased. This implies a certain amount of motion at the wrist (Antón and Polidoro 2000).

Further observations of Individual 48’s left elbow suggest a physical disability. Damage to the joint cartilage is indicated by eburation (fig. 6) observed on the anterior aspect of the radial head (9 mm long, 5 mm wide). The radial head has a sharp projection next to the eburation and slight notches closer to the ulna.

Based on these observations, reconstruction of the range of motion and restriction at the left elbow joint was possible. Two potential positions were considered. In the first one, the radial projection goes into the radial fossa of the humerus and the trochlea into the trochlear notch. This way, the eburinated areas meet. Also, the angle between the humerus and the forearm is about 65 to 70 degrees. The radius and ulna were still able to move (extend-flex) for several degrees at the elbow joint, resulting in damaged cartilage and eburation. Thus, this articulation was affected by secondary osteoarthritis. In the second position, the radial projection goes directly into the coronoid fossa of the humerus. This is possible when the medial border of the inferior trochlear facet meets a notch in the posterior aspect of the capitulum. The angle between the humerus and the forearm is fixed here at about 90 degrees. In both positions, the left forearm was partially flexed at the elbow joint. The change in position and degrees may be related to an attempt of reduction of the condition.
On the right elbow, eburnation is visible on the right coronoid process (9 mm in diameter) as well as on the anterior view of the fragmented distal humerus (3 mm in diameter) (fig. 7). Due to the state of preservation, it is not possible to determine whether it was flexed or extended. According to Antón and Polidoro (2000), long-term fixation of bones in a semi-prone position may be diagnosed by anterior migration of the interosseous crest, reduction, or even absence, of the pronators’ attachments (pronator teres and pronator quadratus) as well as increased development of Lister’s tubercles (Antón and Polidoro 2000). Other muscles probably affected to a certain extent by this fusion are brachialis, brachioradialis, biceps brachii, triceps brachii and/or anconeus, as their origins/insertions attach on the proximal epiphyses of the radius and/or ulna (Antón and Polidoro 2000; Gosling et al. 2008). However, the muscle attachments still visible on Individual 48’s right forearm seem to be normal. Only the Lister’s tubercles appear increased, implying consequent movements at the right wrist (Antón and Polidoro 2000). The authors do not detail the soft tissues’ impact on the muscle attachments when the bones are fixed in pronation, as is Individual 48’s left forearm.

Although fragmented, the distal humeri both appear to have atrophied. Individual 48’s left humerus is quite small and the preserved trochlea fragments are flat with surface irregularities; these observations are consistent with the ulnar heads. The right humerus was too fragmented to confirm but appears to be of the same size and appearance as the left.

In addition, the lateral third of the left clavicle (fig. 9) has a reduced circumference. This atrophic appearance can be explained by restricted movement at the shoulder joint due to the synostosis. Kozín (2009) recognized shoulder compensation in clinical cases of synostosis: abduction for pronation and adduction for supination. This malformation of the clavicle thus indicate that the condition
also affected the shoulder, including deltoid, pectoralis major and trapezius (Gosling et al. 2008; Kozin 2009). Unfortunately, this interpretation is limited because both scapulae and the right clavicle are absent and both humeri are missing their proximal part.

*Figure 7 Left clavicle, inferior view (image from H. Dénom: 2015).*

Nevertheless, the presence of atrophied distal humeri and left clavicle confirms the congenital aetiology of the synostosis. Such osseous defects are regrettably not reported in the osteoarchaeological literature, but clinical data confirms that atrophy of the humerus and clavicle is consistent with congenital synostosis (Aufderheide and Rodriguez-Martin 1998: 73).

**Conclusions**

To conclude this palaeopathological case study, the bilateral proximal radio-ulnar synostosis presented here from Virton (Province of Luxembourg, Belgium) is a rare anomaly explained by a congenital occurrence, probably a congenital anterior dislocation. Traumatic aetiology was rejected based on the osseous evidence, which was not consistent with published case studies. With this synostosis, the atrophic humerus and clavicle, Individual 48 would have been restricted in their movements – especially pronation and supination – forcing at least one of the forearms in a flexed position and damaging the joint cartilage.

Despite state of preservation, it was still possible to reflect on a differential palaeopathological diagnosis as well as on biomechanical implications for this first reported archaeological congenital radio-ulnar synostosis from Belgium. These remains underline the consequences of the condition to the shoulders and wrists. They suggest that it would be valuable to revisit those joints for other previously published cases, if the osseous evidence is available. This case study also serves as a reminder that even fragmented bones can provide significant information about health conditions in past populations.

**Acknowledgments**

The author is grateful to archaeologist Denis Henrotay of the Archaeological Service in the Province of Luxembourg (DGO4, SPW) for permitting access to the materials. Special thanks go to the anthropologists David Gandia, Elizabeth Craig-Atkins, Keith Manchester and David Craps for their insightful advice and to the radiologist for his important support.

**Bibliography**


