Identification of Pathological Lesions on Human Skeletal Remains from the Iron Age Site, Adichanallur (Excavations 2021-2023), Tamil Nadu

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Abstract

The Archaeological Survey of India, Trichy Circle, conducted excavations at the Iron Age site of Adichanallur between 2021 and 2023. The present paper aims to identify and interpret the pathological changes on the skeletal remains recovered from the recent excavations (2021–2023). of. Standard methods were employed for the analysis of remains recovered from twelve urn burials and one pit burial excavated from trenches ZM46 and ZN46 in Locality C. Although all skeletal remains were highly fragmentary, macroscopic examination revealed multiple pathological conditions, including degenerative diseases, such as osteoarthritis and Schmorl's nodes; traumatic lesions, such as an unreduced shoulder dislocation; and various dental pathologies, including caries, enamel hypoplasia, hypercementosis, antemortem tooth loss, and dilaceration. These pathological lesions provide valuable information on habitual activities, nutritional stress, oral health, and dietary patterns of the Iron Age population. The results also show pathological variations across individuals of different age groups; that is, from infants to older adults.

Introduction

Adichanallur (8° 37' 47.6" N; 77° 52' 34.9" E) in the Thoothukudi District, Tamil Nadu, has an extensive well-preserved urn burial site (Fig. 1). It is situated on the right bank of the Tambiraparani River, at about 680 km south of Chennai and about 4 km west of Srivaikundam town. The Iron Age site extends on either side of the Tirunelveli-Tiruchendur Road. The site encompasses an area of 50.6 ha. The site, protected by the Archaeological Survey of India since 1921, is locally referred to as "*parambu*", meaning dry ground, a ridge, or a mound (long stretch of high land) in Tamil (Badhreenath 2020). The site was discovered by A. Fedor Jagor of Berlin, along with Mr. Stuart, then acting Collector of Tirunelveli, and the District Engineer in 1876 (Rea 1915; Leshnik 1974). Though, many scholars like G.E. Smith, B.S. Guha, Solly Zuckerman, and K.A.R. Kennedy (Zuckerman 1930; Kennedy 1986) have studied the Adichanallur skeletal remains, their research was mainly based on the skulls and focused more on the racial identity of Iron Age people of Adichanallur. There is no report of postcranial studies of those skeletal assemblages. Scientific research on pathological and structural abnormalities of the Adichanallur skeletal remains (both cranial and postcranial), was conducted for the first time by Dr. Raghavan Padmanathan (Badhreenath 2020). His study revealed extensive pathological evidence on the bones, including tumour growth, particularly Pott's puffy tumour, sexually transmitted diseases, epidemic infectious diseases, age- and work-related disorders, and others.

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Material

The skeletal remains analysed in this paper were excavated by the Archaeological Survey of India in 2021–2023, and are currently preserved in the repository of the Archaeological Survey of India, Trichy Circle. The anthropological study on selected skeletal remains was conducted in the Anthropological Laboratory of Deccan College, Pune in 2025.

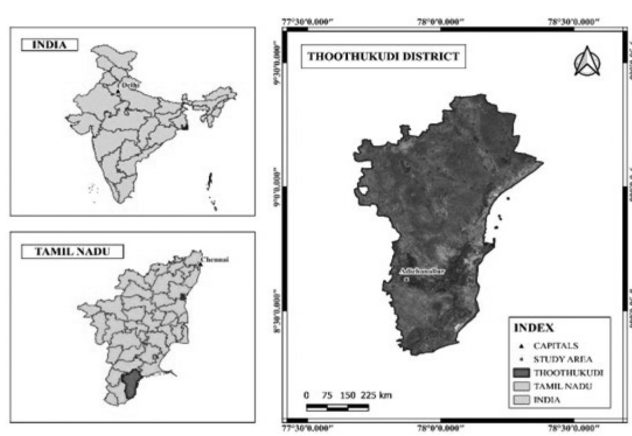

Fig. 1: Location of the site

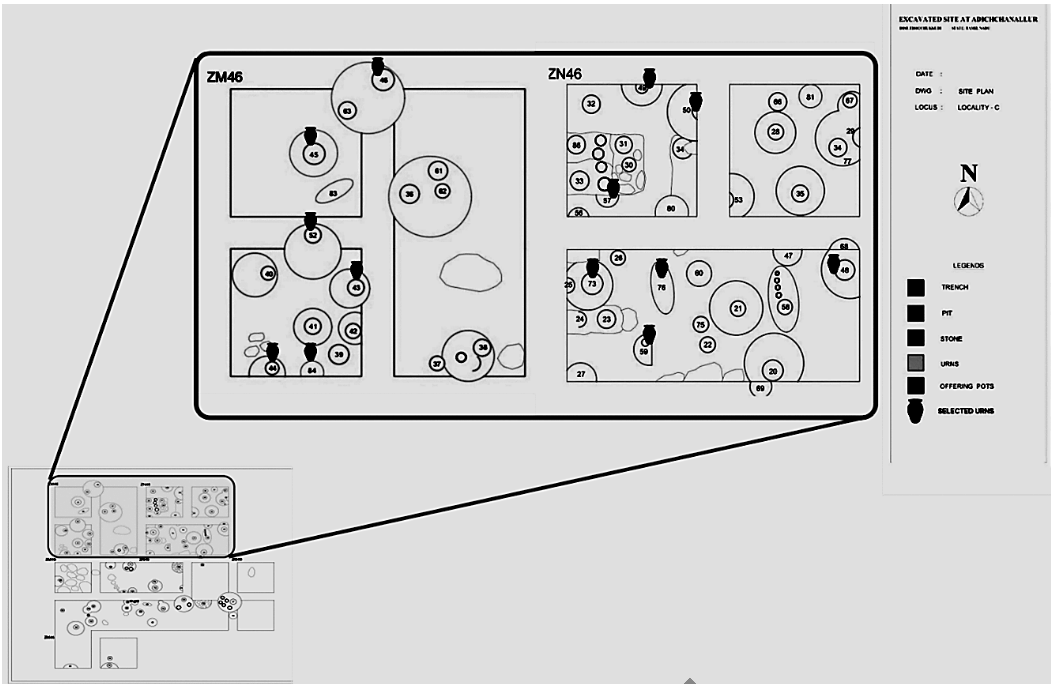

Fig. 2: Site plan of Locality C and the selected urn burials

In total, 12 urn burials and a pit burial (trenches ZM46 and ZN46 from Locality C) were randomly selected (Fig. 2). Out of 17 burials from Trench ZM46, 6 urn burials, including 2 urns (Urn no: 45, 46) from Quadrant I and 4 urns (Urn no: 43, 44, 52 and 84) from Quadrant IV, were studied. Out of the 30 urn burials from Trench ZN46, 6 urns, including 3 urns (Urn no: 49, 50, 57) from Quadrant I, 1 urn (Urn no: 48) from Quadrant III, two urns (Urn no: 59, 73) and a pit burial (Pit no: 76) from Quadrant IV, were studied. The inventory revealed that both the urns 48 and 57 contained the skeletal remains of two individuals each. Accordingly, the skeletons were labelled as 48a and 48b for the individuals from Urn 48, and the individuals from Urn 57 were labelled as 57a and 57b.

Methodology

The bones were so fragmented that restoration was necessary, which involved putting pieces of broken bones back together by observing their thickness, colour, texture, weathering, and fresh cuts. In some instances, an urn contained skeletal remains of more than one individual. Therefore, sorting of the material was also required. Size, age, and sex were given primary importance while sorting the bones. Bone colour and weathering also contributed to this process. Standard methodology was used for examining the skeletal assemblage. Sex was determined using morphological differences of the skull and pelvic features, based on the grading systems given by Brothwell (1981) and Buikstra and Ubelaker (1994). The age was estimated mainly based on cranial suture closure and dental attrition (Buikstra and Ubelaker 1994), and dental crown formation and eruption (Bass 1981). The bones affected by pathologies were identified, observed and studied carefully. Visual or macroscopic analysis was carried out to diagnose the pathologies.

Results

Several significant pathologies were observed on the selected skeletal series (Table 1). The major pathologies observed on the skeletal remains are shoulder dislocation, degenerative diseases such as osteoarthritis and Schmorl's node, and dental pathologies such as antemortem tooth loss, dental caries, hypercementosis, enamel hypoplasia and root dilaceration.

Shoulder Dislocation

The dislocation in the joint, where the glenoid cavity of the scapula and the head of the humerus are articulated with each other, is called shoulder dislocation or shoulder luxation. Accidents and injuries because of intense physical activities or a fall onto an outstretched hand may cause a dislocation in the shoulder components (Waldron 2009). It is the most commonly dislocated joint in the body, and the most common cause of this dislocation is the indirect force (Rockwood 1975). Such trauma results from a rapid and forceful movement of the upper arm away from the body,

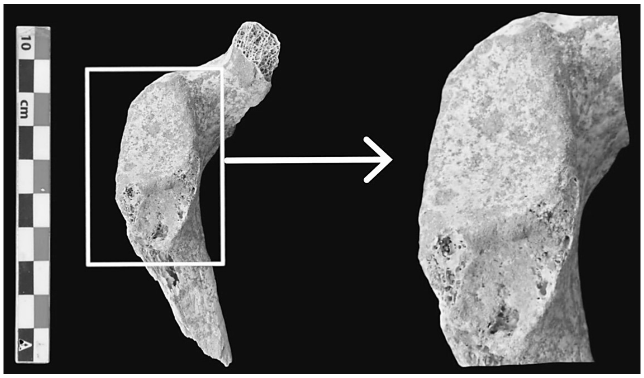

Fig. 3: Shoulder dislocation in individual no. 46

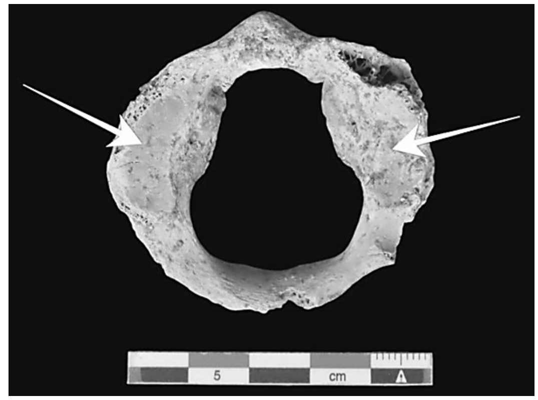

Fig. 4: Eburnation on both superior articular surface of C1

along with external rotation (Ortner and Putscher 1981). In most cases, shoulder dislocation is anterior and usually reduces without difficulty except in the cases of Bankart and Hill-Sachs lesions (Waldron 2009).

In urn 46 of quadrant I, from the skeletal materials recovered, dislocation was observed in the glenoid cavity of the right scapula (Fig. 3). The individual is most likely an adult, and the exact age is not possible to determine, as there were no teeth or any other markers available in this collection. Given the fragmentary condition of the assemblage, sex determination was not possible..

Osteoarthritis (OA)

Osteoarthritis is a joint disease primarily associated with synovial joints, which are the most common type of joints in the body. It is one of the most commonly observed pathological conditions affecting the skeleton (Waldron 2009). Synovial joints allow a wide range of movements and are characterised by articular surfaces covered with hyaline cartilage, and is followed by a thin synovial membrane that lines the joint cavity. This membrane produces synovial fluid, a viscous lubricant that reduces friction between the articulating bones (Standring 2015).

OA is a chronic disease, and therefore, it has its own way of developing stages. The major factors that are responsible for OA are age, sex, obesity, bone density, underlying systematic conditions, underlying localised conditions, bipedal biomechanics and malformation (Burt *et al*. 2013). The progression of osteoarthritis can be divided into three main stages: the first stage is the weakening of articular cartilage, the second stage is the cartilage breakdown, and the third stage is that the cartilage fragments lead to an inflammatory reaction in the synovial membrane (Rogers and Waldron 1995). As this damage continues, the bones in the joint also change. Eburnation is the most important symptom to diagnose OA, but any two of the other symptoms, including marginal osteophytes or lipping, pits and holes, change in the shape of the joint and new bone growth on the joint, can also be used to diagnose OA (Waldron 2009).

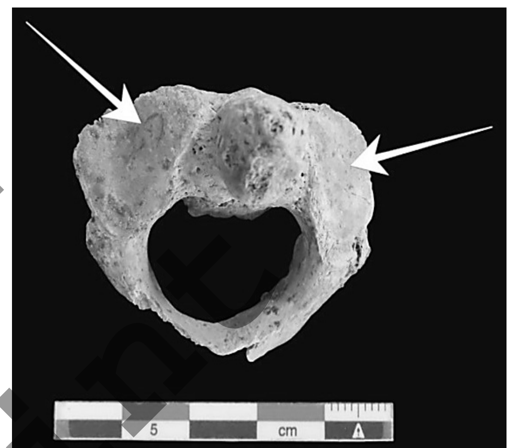

Fig. 5: Eburnation on both superior articular surface of C2

From the material studied, many displayed the above-mentioned symptoms. The vertebral remains (of individual 57a) recovered from Urn 57 show multiple degenerative changes. The individual is old and most likely a male. The cervical vertebrae, i.e., C1 (Fig. 4) and C2 (Fig. 5), show degenerative changes like eburnation on both superior articular facets of C1 and C2. The C5 vertebra (Fig. 6) shows marginal osteophytes on the body edges, anterior lipping which altered the shape of the vertebra, and the presence of pits and holes on one side of the body portion.

In the thoracic region, T1 (Fig. 7) has pits and holes on the vertebral body, while T2 (Fig. 8) shows marginal lipping and changes in the shape of the articular surface. The T9 (?) vertebra (Fig. 9) is notably deformed with significant alteration in the shape of the lamina, lipping along the vertebral body margin, and marginal osteophyte development on the superior articular facets. The second lumbar (L2) vertebra (Fig. 10) shows the presence of pits and holes on the vertebral body. It also shows alteration in the shape of the superior articular surface and marginal osteophytes along the vertebral body edges. In addition to this, five unidentifiable vertebral fragments show various

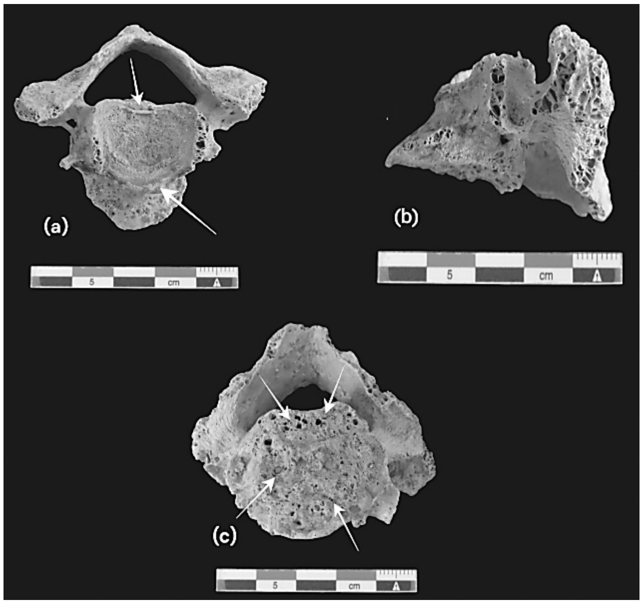

Fig. 6: Superior, lateral and inferior views of C5 (a) Marginal osteophytes, (b) Lipping, (c) Pits and holes

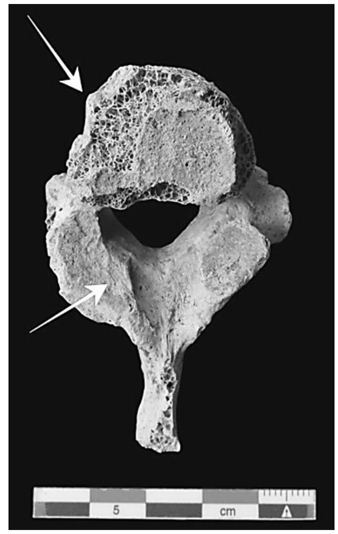

Fig. 8: Changes in the shape of the articular surface and lipping in the margins of body of T2

Fig. 7: Pits and holes on the body of T1

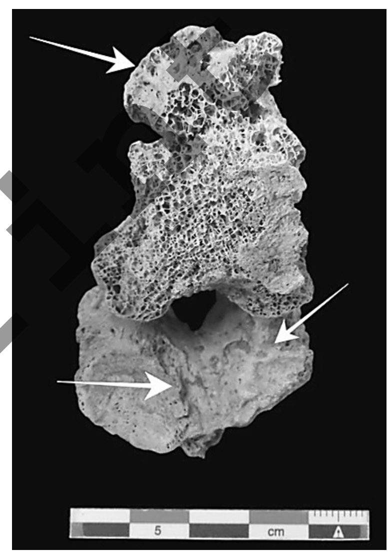

Fig. 9: Lipping on the margin of the body and changes in the shape of T9(?)

degenerative features such as lipping, eburnation and porosity. All the above degenerative changes are symptoms of osteoarthritis.

Intervertebral Disc Degeneration and Schmorl's Nodes (SN)

Schmorl's nodes are the result of intervertebral disc degeneration. Compression and expansion of intervertebral discs help in the movement of the vertebral column. The intervertebral disc degeneration involves degeneration of both the nucleus pulposus and the annulus fibrosus, leading to outward bulging of the nucleus and collapse of the annulus. This process often leads to reduction in joint space and is metaphorically compared to a "flat tyre" appearance (Waldron 2009).

The intervertebral disc degeneration may lead to herniation of the disc, which results in depression in the vertebral bodies, and these depressions can be deep or shallow (Ortner and Putschar 1981; Burt *et al*. 2013). These are called Schmorl's nodes. They can occur in

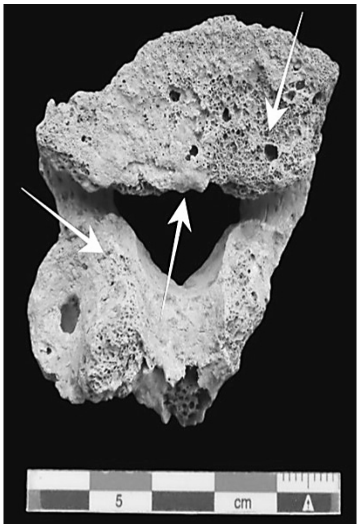

Fig. 10: Pits and holes, marginal osteophytes at the edge of the body and changes in the shape of the articular surface of L2

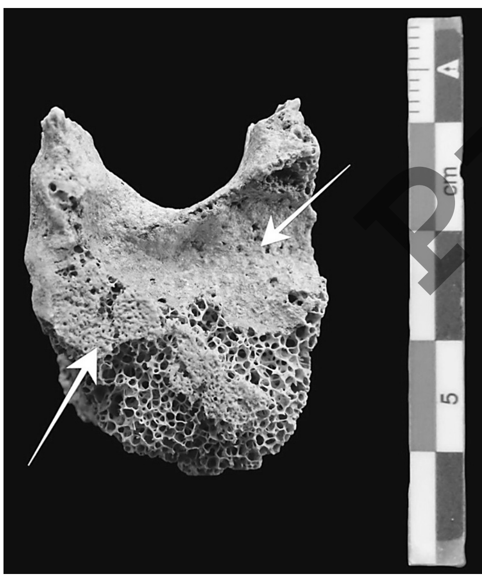

Fig. 11: Schmorl's nodes on T5

a variety of shapes and in any position of the vertebral surface (Waldron 2009).

Schmorl's nodes were noted on the fifth thoracic vertebra (T5) (Fig. 11) of the individual from Urn 73, appearing as a partial depression on the surface of the vertebral body. These depressions and lipping result from intervertebral discs pressing into the vertebral body, typically associated with significant spinal loading. It significant to note here that the skeletal remains from Urn 73 are of a young adult female, i.e., between 18 and 25 years old.

Antemortem Tooth Loss

To determine whether a tooth has been lost before (antemortem) or after (postmortem) death, the important indicator is the condition of alveolar bone. Postmortem tooth loss is typically identified by the presence of a deep un-remodelled socket, as no healing of alveolar bone or jawbone remodelling occurs after death. On the other hand, antemortem tooth loss is characterised by varying degrees of bone remodelling around the socket, indicating the response of the body to the tooth loss during life. When multiple teeth are missing, the relative degree of socket remodelling is used to infer the sequence of tooth loss. If the tooth loss occurred several years prior to death, extensive remodelling may result in a completely remodelled jaw. In individuals who were edentulous, particularly in the mandible, it leads to a significant reduction in the size and bulk of the mandible (Pietrokovski *et al*. 2007).

In most of the cases, it is not possible to determine the exact cause of tooth loss. However, if there is clear evidence of extensive periodontal disease, it is reasonable to infer that this condition was the primary factor contributing to the missing teeth (Waldron 2009).
The individual 57a (from the urn 57), who is an old male, showed antemortem tooth loss (Fig. 12) in the mandible. He had only one tooth, i.e., the right canine (RC), at the time of death. The posterior teeth (Pm1, Pm2, M1, M2, M3) were lost a long time before the death of the individual because the alveolar bone is almost completely

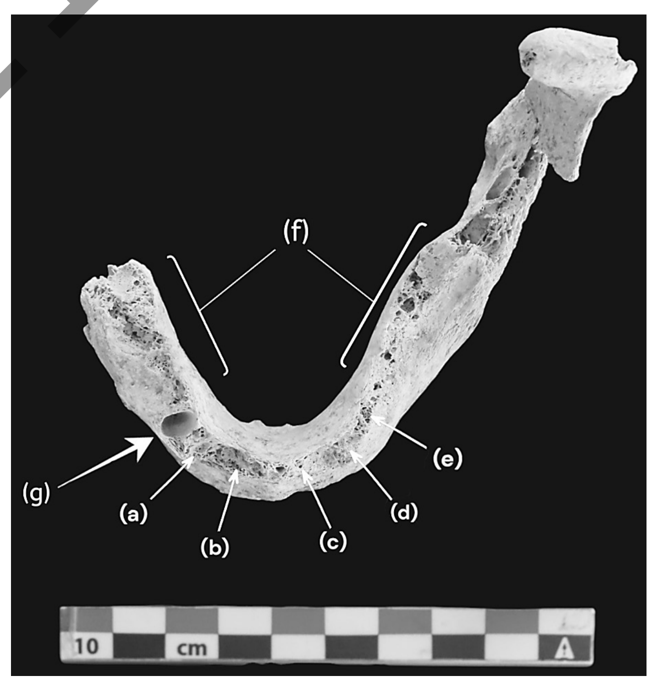

Fig. 12: Antemortem anterior teeth loss – (a) RI2, (b) RI1, (c) LI1, (d) LI2, (e) LC. (f) Antemortem posterior teeth loss where the sockets are almost completely invisible. Postmortem tooth loss – (g) Socket of RC

healed and the jaw is fully remodelled at the posterior portion of the jaw. Whereas the alveolar bone of the anterior teeth (I1, I2, C) was not healed completely, it was in the process of remodelling the jaw, which indicates that they were lost after some period of posterior teeth loss and some years before the death.

Dental Caries

Dental caries is a common dental disease in archaeological skeletal remains. There are two different types of dental caries, i.e., coronal caries and root surface caries. Coronal caries begins in the enamel and progresses into the dentine, potentially reaching the pulp and causing inflammation. Root caries, common in older individuals, occur when gum recession exposes the root surface. These lesions develop slowly but quickly penetrate the thin cement layer, reaching the underlying dentine (Hillson 2001).

Caries develops through a multi-factorial process requiring plaque, fermentable carbohydrates, and acid production. Streptococci and lactobacilli in the biofilm metabolise sugars into organic acids, lowering the pH. When the pH drops below a critical level, it leads to the demineralisation of tooth tissues, initiating carious lesions (Waldron 2009).

In Urn 43, occlusal caries have been observed on the surface of mandibular RM2 (Fig. 13), and in Urn 52, occlusal caries can be seen in maxillary RM1, RM2 and LM3 (Fig. 13). In Urn 73, dental caries was observed in a single tooth, i.e., the mandibular second molar (RM2) (Fig. 13). The lesion originated in the grooves of the occlusal surface, characteristic of occlusal caries, which comes under the category of coronal caries. These typically begin in the intricate fissures, fossae, and grooves of molar and premolar crowns. Caries can also originate in buccal pits at the ends of fissures on molar sides or in lingual pits occasionally found on upper incisors (Hillson 2001).

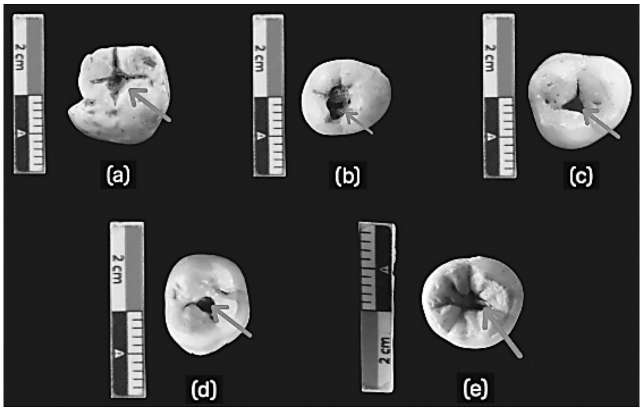

Fig. 13: Caries on the occlusal surface of (a) mandibular RM2, (b) maxillary RM1, (c) maxillary RM2, (d) maxillary LM3, (e) mandibular RM3

Fig. 14: Hypercementosis on LM3

Hypercementosis

Hypercementosis is the overproduction of cementum on the root of the tooth. This will lead to bulbous and irregularly bulging roots. It can be detected more in dental radiographs. The real cause of this disease is unknown. However, it can be related to continued eruption and heavy wear or attrition (Hillson 1996). From Urn no. 73, one mandibular tooth, i.e., LM3, has hypercementosis (Fig. 14), on which three-fourths of the root is covered with excessive cement. There is no complete eruption or heavy wear on the tooth.

Enamel Hypoplasia

Enamel hypoplasia is a developmental defect of the tooth enamel that results from a disruption in the activity of ameloblasts during enamel formation (Goodman and Armelagos 1985). It is visible as pits, grooves, or lines on the enamel surface and is often associated with episodes of stress, infectious diseases, genetic causes, toxic causes, developmental disturbances, malnutrition, and systemic illnesses (Mays 2002). In bioarchaeology, enamel hypoplasia is widely used as a marker for physiological stress in ancient populations and indicators of nutritional and disease status in palaeopathology (Goodman and Rose 1990, 1991). There are three types of enamel hypoplasia, furrow-type defects or linear enamel hypoplasia; pit-type defects or localised enamel hypoplasia; and plane-type defects (Hillson 1996). The linear enamel hypoplasia, which appears in horizontal grooves, and localised enamel hypoplasia are characterised by circular defective areas of thinned or missing enamel on the labial surface. The individual from Urn 59, who is a child (3.5-4 years old), had enamel hypoplasia on the teeth, including the maxillary tooth (LC) and mandibular teeth (LI1, LI2 and RC). Two different types of enamel hypoplasia were noticed on these teeth, and they are linear enamel hypoplasia (on mandibular RC and LI2) (Fig. 15)

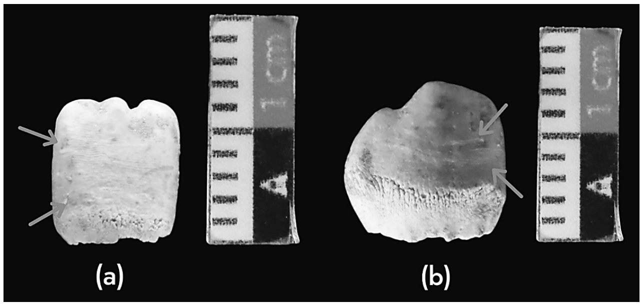

Fig. 15: Linear enamel hypoplasia in mandibular (a) LI2 and (b) RC

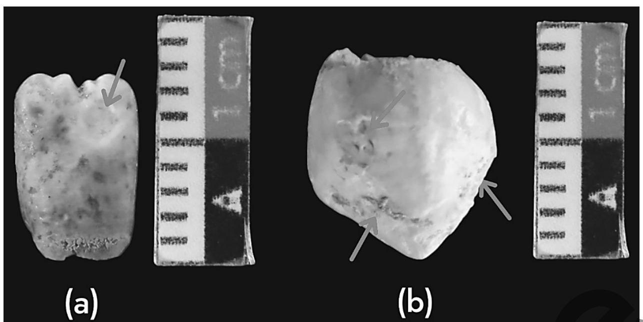

Fig. 16: Localised enamel hypoplasia in (a) mandibular LI1 and (b) maxillary LC

and localised enamel hypoplasia (on maxillary LC and mandibular LI1) (Fig.16).

Root Dilaceration

Root dilaceration is a dental anomaly characterised by a sharp bend or curve in the root of a tooth. It mostly affects the posterior teeth, particularly the molars, but can occur in any tooth. It can occur in either the mesiodistal or buccolingual direction. The cause of the condition can be

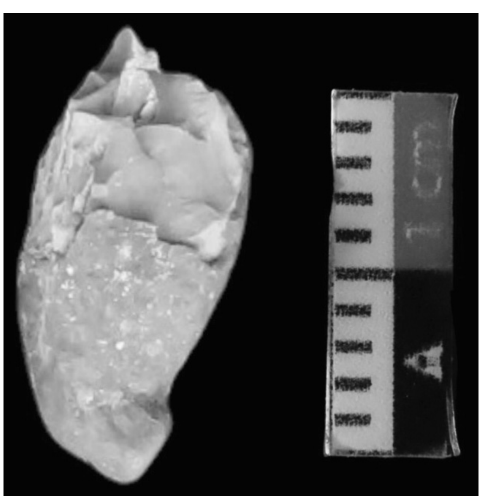

Fig. 17: Root dilaceration on root fragment

mechanical trauma during tooth development (Hamasha *et al*. 2002).

The urn 57 contained several root fragments of individual 57a. One of the root fragments (Fig. 17) displays root dilaceration. It is not possible to determine which tooth this root belonged to, as the root is broken.

Discussion

Despite the limited sample size and poor preservation condition, we obtained ample amounts of pathological evidence from the skeletal remains. It is also important to note that the majority of the pathologies were observed in the skeletal remains from the primary burials. These primary burials have preserved almost complete skeletal remains, allowing detailed macroscopic study on them.

Several taphonomic changes in the postmortem processes were observed on the bones. All bones were extremely damaged, none is complete. Most of them were eroded and fragmentary, probably because of waterlogging and erosive soil conditions. Black pigmentations, possibly due to soil minerals or bacteria that are present in the depositional environment were observed on some bones. Behrensmeyer (1978) divided the weathering of the bone into five stages. The status of almost all the skeletal remains of the current research can be categorised under stage five. This includes the bones that fall apart with large splinters; bones easily broken by moving; the original bone shape may be difficult to determine; cancellous bone is usually exposed, when present, and may outlast all traces of the former more compact, outer parts of the bone. The shape of some bones has also changed because of the soil pressure.

Palaeopathological assessment revealed various conditions across the skeletal assemblage. One remarkable pathology noted in this assemblage is shoulder dislocation at the right scapula from urn no. 46. This indicates a traumatic event, probably the result of substantial downward force either from a heavy object falling on them or from lifting a substantial weight. In this case, the dislocation is unreduced, which means the person might have been bearing this dislocation without any treatment for a long period of time, resulting in the formation of a new joint surface for the articulation of the humeral head with the scapula. However, no further explanation is possible, as this is a secondary burial and a few skeletal remains are available for study. Similarly, the sex determination is also not possible, only adult status can be assigned to this individual.

The skeletal remains of individual no. 57, a primary burial, belongs to an old male individual and contains many vertebral bones with symptoms of osteoarthritis. The vertebral bones, including C1, C2, C5, T1, T2, T9 (?), and some unidentified vertebral fragments, show severe osteoarthritis. More than one pathological condition, including antemortem tooth loss and root dilaceration, is also observed in this individual. The arthritis lesion is a degenerative pathology, and the evidence of antemortem tooth loss is consistent with the old age of the individual. The root dilaceration on one root fragment might be due to the mechanical trauma during tooth development.

Interestingly, the evidence of Schmorl's nodes viewed on the skeletal remains of individual no. 73, is identified as a young adult female. Generally, the lesion is observed in older individuals. But, the early onset of intervertebral disc degeneration, resulting in changes in the vertebral bone, such as Schmorl's nodes, is seen on this female skeleton. This could be indicative of the habitual stress. She might have been involved in physical activities that caused pressure or strain on her vertebral column, such as bending, heavy lifting, or repetitive movements.

Other than degenerative disease, early-age physiological stress is identified as enamel hypoplasia in the teeth of a child from urn no. 59, aged approximately 3.5 to 4 years. The child had a mixed dentition, including both deciduous and permanent teeth, at the time of death. The permanent teeth were in the process of complete crown formation. On these permanent teeth crowns, enamel hypoplasia was observed. A study conducted by Corruccini on children's teeth from a population of Barbados slaves (dated to the 17th to 19th centuries CE) found that most enamel defects formed between the ages of 3 and 4 years, and it was suggested that children of this population were weaned later than normal (Corruccini *et al*. 1985; Roberts and Manchester 2010). Weaning can be a significant source of stress contributing to the development of enamel defects (Larsen 1997). It is a vulnerable period because of the increased nutritional stress due to the loss of proteins and nutrients, especially immunoglobulins, provided by breast milk (Ogden 2008). Enamel hypoplasia on the teeth of individual no. 59 likely reflects physiological stress during weaning. Bunon (1746) first documented enamel hypoplasia, later observed on unerupted teeth of children with rickets, scurvy, measles, and smallpox, confirming defects form during crown development (Hillson 1996). However, enamel hypoplasia alone cannot diagnose specific conditions, and the limited skeletal remains of individual 59 preclude further confirmation.

Dental remains of three individuals, such as individuals no. 43, 52 and 73, contain teeth with dental caries. It can be interpreted that these individuals might have had poor oral hygiene or a high intake of carbohydrate-based food. The archaeobotanical studies in the report published by the Archaeological Survey of India on the Adichanallur excavation season 2004-2005 show that the ancient settlers at Adichanallur had cultivated both rice and green gram (Badhreenath 2020). Both rice and green gram contain carbohydrates, and the regular consumption of these might have contributed to dental caries.

Conclusions

Of the fifteen individuals studied, bones with pathologies have been identified in the skeletal remains of six individuals, particularly individuals numbered 43, 46, 52, 57a, 59 and 73. The first three are from Trench ZM46, and the latter three are from Trench ZN46. Even though the sample size is small, it helps to understand the disease pattern and health of the people during the Iron Age at Adichanallur. The study revealed various pathological conditions affecting individuals belonging to different age groups. Pathological evidence includes traumatic injuries such as an unreduced shoulder dislocation in an adult (?) individual, degenerative diseases such as osteoarthritis in an old individual, Schmorl's nodes in a young adult individual and dental pathologies like enamel hypoplasia in a child, and dental caries in three adults. All this evidence shows the physiological stress, dietary habits and oral health of the population. This research constitutes a preliminary yet systematic bioanthropological study of the Adichanallur skeletal series.

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