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THE MOST PROMINENT SCOLIOSIS IN ANCIENT ANATOLIAN POPULATIONS: EXAMPLE OF SİNOP BALATLAR ORTHODOX CHURCH

Mustafa Tolga ÇIRAK and Emel ACAR

Department of Anthropology, Faculty of Arts and Sciences, Hitit University, Çorum, Turkiye

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**Corresponding author: Mustafa Tolga Çırak (mtolgacirak@hitit.edu.tr)*

ABSTRACT

Scoliosis is a lateral deviation of the spine from the mid-sagittal plane. Scoliosis is a descriptive term, not a diagnosis. The spine of a person with scoliosis is more like the letter "S" or "C" than a straight line. The aim of this study is to understand what scoliosis is, how scoliosis is detected in paleopathological studies, and to describe the scoliotic skeleton found in Sinop Balatlar Church Excavation in 2019. The Balatlar Church building complex was used as a cemetery by Orthodox Christians from the 17th century to the beginning of the 20th century. Although many rare pathologies have been encountered in paleopathological studies on Anatolian societies, the number of samples in which scoliosis is so prominent is almost absent. With this study, it is aimed to contribute to this field. The skeletal pathology of an elderly woman over 65 years of age has been contributed to the literature by determining the degree of scoliosis both in the laboratory environment and with computed tomography images.This study will provide an important literature for future paleopathology studies.

KEYWORDS: paleopathology, osteometers, scoliosis, Sinop Balatlar Orthodox Church

1. INTRODUCTION

Anatolia is an important place that has hosted many different civilizations for many years. It is located at the intersection of the European and Asian continents. Traces of many different civilizations throughout history are unearthed in excavations. The human remains obtained from the excavations made in order to understand Anatolia and Ancient Anatolian societies have provided many information about the past societies to come to light. In addition to the demographic characteristics of these societies, it is possible to determine their health status thanks to their skeletons. In the paleopathological studies conducted on Anatolian people in the past, many different diseases that reveal the health structures of societies have been detected. While some pathologies are widespread throughout the society (such as osteophytes, trauma, anemia…), some specific pathologies are rarely encountered. In particular, vertebral anomalies are among the most common pathologies encountered in Anatolian populations, while the incidence of some pathologies such as scoliosis in ancient times was quite low. Vertebral disorders are sometimes caused by wear due to use, and sometimes appear as an innate feature. In this study, the most prominent example of scoliosis detected on ancient Anatolian societies, seen in the M-24 skeleton obtained from the Balatlar Orthodox Church, is discussed. Vertical position of the spine in humans; Stays in balance with neuromuscular control such as bone and fibrous supporting structures. Scoliosis is the term used for the deviation of the spine laterally from the midsaggital plane (Ortner, 2003).

Scoliosis, which means to bend and twist, is a Homeric word. Hippocrates, who lived in the 5th century BC, used the term Scoliosis for the first time (Vasiliadis et al., 2009). Hippocrates first used the definition of scoliosis for all spinal curvatures. In his works, he stated that there are two possible causes of spinal curvature: Tubercle nodules accumulated in the lungs and, in some cases, the position that patients are accustomed to in bed and the curvature in the posture (Lovett, 1913). Hippocrates commented on diet and extension for scoliosis treatment. In his work titled On Articulations, he described Hippocrates' ladder, Hippocrates' board and Hippocrates' bench techniques, which are methods of treating spinal curvatures (Vasiliadis et al., 2009). In 650 AC, Paul of Aegina recommended treatment with wooden sticks (splint) in cases of curvature of all varieties. About 500 years later, Albukasis declared that no one's sideways curvature could be cured. Ambroise Paré, born in 1510, termed a bunch of protruding vertebrae as Greek kyphosis and the flattened as lordosis. However, the joints to the right or left and look just like the letter "S" he called it scoliosis (Figure 1) (Lovett, 1913). He treated with steel corsets to correct the deformity in soldiers (Bedre, 2019). The first autopsy with scoliosis was examined and reported by Fabricius Hildanus in 1646 (Lovett, 1913). Samuel Hare thought in 1849 that scoliosis was caused by sitting habits and metabolic bone diseases. Hare corsets do not provide any benefit for treatment; He suggested that regular nutrition, breathing and bed exercises are important in treatment (Bedre, 2019). Russell A. Hibbs used the fusion technique applied in spinal tuberculosis in 1911 in the treatment of scoliosis in 1914 to prevent the progression of the deformity. Thus, the foundation of scoliosis surgery was formed (Bedre, 2019).

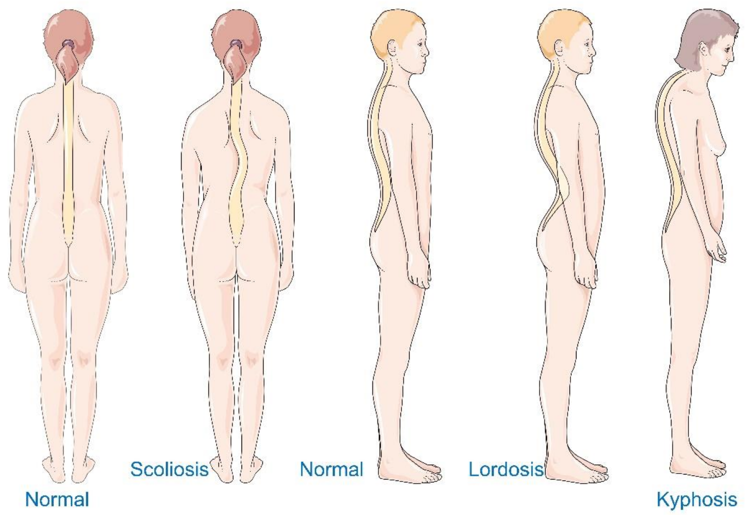

Figure 1. Posture of healthy individuals with scoliosis, lordosis and kyphosis. (https://www.osteopatastefanomassetti.it/la-scoliosi-postura/ Last Accessed: 25.10.2022)

The most comprehensive scoliosis classification currently valid was made by the Scoliosis Research Society (SRS) in 1973 (Bedre, 2019).

The spine of a person with scoliosis is more like the letter "S" or "C" rather than a straight line. These curvatures can cause the shoulder and waist area of the person to appear unstable. Some of these bones may also have a slight twist, making one shoulder more prominent than the other. Scoliosis is a descriptive term, not a diagnosis (Scoliosis Research Society - SRS).

Scoliosis has multiple etiology. It is usually accompanied by congenital malformations of the spine (hemivertebra, block vertebra, congenital impression, transitional vertebra). These types of scoliosis are called congenital scoliosis. Congenital scoliosis is less common than idiopathic scoliosis. (Aufderheide et. al., 1998).

The cause of more than 80% of the cases is unknown. This type of case is called "idiopathic", meaning the cause is unknown. Idiopathic scoliosis is called "infantile" in 0-3 year old children, "juvenile" in 4-10 year old children, "adolescent" in 11-18 year old adolescents, and "adult" over 18 years old (Scoliosis Research Society - SRS).

Infantile scoliosis: Its incidence is less in men, usually the involvement of infantic scoliosis occurs in the thoracic region and is located on the left side. More than 75% of patients have plagiocephaly (a trapezoidal head) and hip dysplasia is also common (Aufderheide et. al., 1998).

Juvenile scoliosis: It shows the family's health history, although some statistics say that juvenile scoliosis is more common in women, it is seen equally in both sexes. As in the adolescent type, involvement is observed in the lumbar and thoracic region. Curvature usually occurs on the right side (Aufderheide et. al., 1998).

Adolescent scoliosis: Heredity has many causes. Usually the curvature is on the right side, as in the childhood type. Women are more affected than men (Aufderheide et. al., 1998).

Paralytic scoliosis is less common than idiopathic, it is observed in the thoracalumbar region. It occurs as a result of the reduction of spinal muscles by neurological diseases such as poliomyelitis (polio), cerebral palsy or muscular dystrophy. The results are structural and include pathological slant and postural instability (Aufderheide et. al., 1998).

Scoliosis is not caused by carrying heavy things, athletic activities, sleeping and standing postures, or slight leg length differences (Scoliosis Research Society – SRS).

Ortner and Putschar proposed several techniques for the diagnosis of scoliosis in dry bone in 1985.

1. The transverse processes of the thoracic vertebrae change backward in convex and forward in concave.
2. The transverse processes of the lumbar vertebrae are short; convex blunt; It is long, thin and pointed in the concave.
3. The spongiosa structure of the stacked side of the vertebra shows sclerosis in the concave, and a decrease in the number and size of the convex trabeculae (Aufderheide et. al., 1998).

The ribs (sternum, rib cartilage) curve according to spinal deformity and adapt to their shape. Usually separated in convexity, pressed by concavity. Costovertebral articular facets vary in location and size of the necks of the ribs. Length, width, and slope vary with modified growth and remodelling. If the slope is excessive, new formations such as ankylosis of the costovertebral joints and joints between the ribs occur irregularly (Ortner, 2003).

Scoliosis is one of the rare pathologies seen in past populations. However, it is very difficult to detect individuals with scoliosis due to both carelessness and difficulty in identification during excavations. This study aims to contribute to the literature of one of the most prominent examples of scoliosis in Anatolia. In addition, to increase attention to this issue in paleopathological studies on Ancient Anatolian populations.

2. MATERIAL AND METHOD

2.1. *Material*

The Balatlar Orthodox Church, where the M 24 skeleton was recovered, is located in the city center of Sinop (Map 1). Archaeological excavations started in 2010 with the decision of the Ministry of Culture and Tourism of the Republic of Turkey and the permission of the General Directorate of Cultural Heritage and Museums.

As a result of the excavations carried out in the remains of the building known as the Balatlar Church (Figure 2), the building was used from the Late Roman period until the beginning of the 20th century. The Balatlar Church building complex has been used as a cemetery by Orthodox Christians since the 18th century (Köroğlu, 2019). The most extensive information about the Balatlar Church is found in the publications of Bryer and Winfield (Brayer et al., 1985). In the works of Bryer and Winfield, information is given about the historical background of the building and its phases of use in different periods, and the remains of the Balatlar building complex are defined as the remains of a bath-gymnasium-palestra dating back to the Late Roman period (2-3rd century) (Brayer et al., 1985). It is mentioned that it was used as a monastery and a church during the Eastern Roman Empire (6th-7th centuries), a grain warehouse (granarium) between the 11th and 13th centuries, and it was converted into a monastery after the region was taken by the Turks (Brayer et al., 1985). The church, whose walls are adorned with frescoes, was used until the first quarter of the 20th century, and is the most important of the building remains.

The cemetery area of the excavation carried out under the direction of Gülgün Köroğlu in 2019 was studied by the Department of Anthropology of Hitit University.

In the study, 24 graves with complete integrity were identified. However, mixed skeletons were encountered on the surface, and these skeletons were also taken from the surface and demographically analyzed. As a result of this demographic analysis, a total of 149 human skeletons were identified. In the cemetery area of the Balatlar Church, the SBK M-24 tomb, which is the subject of the study, was found in the D1 trench in the X'numbered place. This tomb, which is in simple soil type, is 185 cm long and 58 cm wide. Skeletal remains of 8 individuals were found in the grave. While 8 different human skulls were located next to the individual SBK M24-1, the body bones outside the skull were collected at the foot of the individual M24-1 (Figure 3). While the SBK M24-1 skeleton, which is the subject of the study, was determined almost completely, most of the body bones of the skeletons of other individuals found in the same grave were not included in the grave. Therefore, the skeleton numbered SBK M24-1 in this burial structure was determined as the last individual placed in the grave. The skeleton was oriented facing east, its hands were folded on the abdomen, and its legs were positioned straight and it was laid on its back. This tomb was not used again after the 19th century. While the skeletons were unearthed, extreme curvature of the femurs and subsequently the anomaly in the vertebrae immediately drew attention.

Map 2. Location Of Sinop Balatlar Orthodox Church On The Map

Figure 2. Sinop Balatlar Church and Tomb 24

Figure 3. Tomb 24

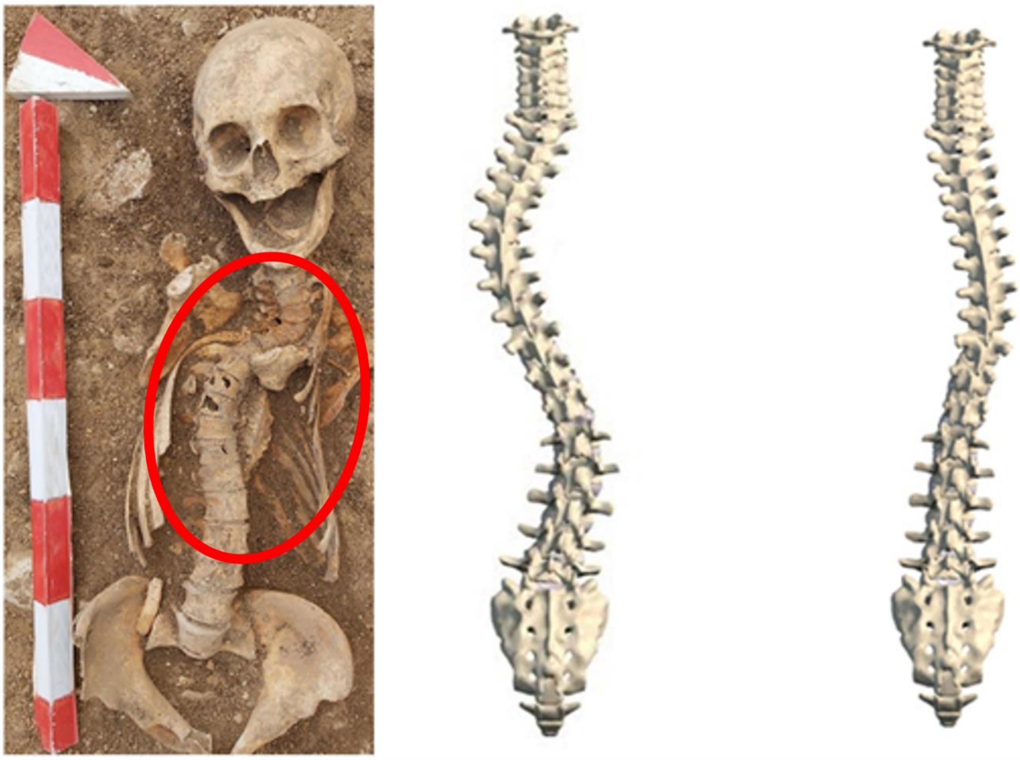

Figure 4. Tomb 24, S-shaped scoliosis detected in the 1st individual (by photo: M. Tolga ÇIRAK). S-type and C-type scoliosis cuves (https://eorthopod.com/scoliosis/, accessed on: 02.11.2022)

2.2. *Method*

The skeleton numbered SBK19M24B1 was removed from the excavation area and brought to the Laboratory of the Anthropology Department of Hitit University. After the cleaning and repair of the skeleton was completed (Figure 5), the age and gender determination study was carried out. Finding all parts of the skeleton, which is the subject of the study, made it possible to determine a healthy age and gender. Using the resources of WEA (1980), Buikstra and Ubelaker (1994), White and Folkens (2005), it was determined that the gender was female by macroscopic analysis. Age determination was made by evaluating the symphysis pubis in the pelvis (McKern et al., 1957) and auricular surface morphologies (Lovejoy et al., 1985), the degree of closure of the sutures in the skull (Olivier, 1969). As a result of the macroscopic examination of the skeleton, it was determined that the gender was female and the age was over 65 years. M-L: Medial – lateral, A – P: Anterior – posterior widths were taken from the processus condylaris mandibulae in the mandible, and M-L, A-P width and depth measurements were taken from the glenoid mandibular fossa in the cranium. (Fig. 5) Length measurements were taken from the extremity bones by anthropometry. X-ray images of the vertebrae, right and left femur were obtained separately. X-ray images were taken with a Toshiba Aquilion CT Scanner imaging device.

Fig 5. Processus condylaris mandibulae M-L: Medial – lateral, A – P: Anterior – posterior

Table 1. Measurements from Processus condylaris mandibulae and glenoid mandibular fossa.

	Processus condylaris mandibulae (cm)		Glenoid mandibular fossa (cm)	
	Right	Left	Right	Left
Width (M-L)	1,9	2,1	1,7	2
Width (A-P)	0,9	0,9	0,9	0,9
Depth			0,8	0,6

Temporalmandibular joint; It is important for the human body as it provides important functions such as chewing, swallowing and speaking (Levangie et al., 2001; Piette, 1993; Stone et al., 2020). Temporalmandibular joint; It consists of three elements: the mandibular condyle, the articular eminence of the temporal bone, and the synovial spaces containing the articular disc, the dense fibrous tissue that divides each joint in two (Stone et al., 2020). It was observed that the right glenoid mandibular fossa of the individual with scoliosis was 0.2 mm narrow compared to the processus condylaris mandible, and the left glenoid mandibular fossa was 0.1 mm narrow compared to the processus condylaris mandible. While the width of the processus condylaris is due to the temporamandibular joint deformation due to arthritis in the mandible of an elderly woman, antemortem tooth loss in the entire mandible and maxilla provides information that this individual has difficulty while performing the chewing movement.

Table 2. Pearson, Trotter and Sağır height-length regression results according to humerus, femur and tibia length of an individual with scoliosis.

	Pearson (1899)	Trotter (1958)	Sağır (2000)
Humerus	71,475+2,754*H **147,4854 (cm)**	2,89*H+78,10 **157,864 (cm)**	2,437*H+84,487±3,99 **151,7482±3,99 (cm)**
Femur	72,844+1,945*F **138,7795 (cm)**	2,32*F+65,53 **144,178 (cm)**	1,830*F+81,158±3,17 **143,195±3,17 (cm)**
Tibia	74,774+2,352*T **148,862 (cm)**	2,42*T+81,83 **158,06 (cm)**	2,073*T+87,696±3,58 **152,9955±3,58 (cm)**

According to the paelodemographic evaluations, the age of the individual with scoliosis was 65+. Height calculations were made using the formulas of Trotter and Gleser (1958) and Sağır (2000). The height of the individual was determined as 153,305 cm by taking the average of the measurements taken from the tibia by Pearson, Trotter, Gleser, and Sağır. Since the excessive curvature of the femoral bone would not give a healthy result in height measurement, the tibia was taken as the basis.

Figure 6. Skeleton (SBK19M24B1) of 65+ years old female individual excavated from the cemetery area of Sinop Balatlar Church

The anatomical structure of the spines of the skeleton is S-shaped. The deviation in the spine started from T2 and ended at T6. The curvature occurred on the right side of the individual. In the measurements made with goniometer, it was determined that the posterior angle of the cervical vertebrae was 84°, the anterior angle of the throcal vertebrae was 150°, and the posterior angle of the lumbar vertebrae was 131° (Figs 6, 24).

When vertebrae were examined in detail, it was observed that especially the cervical and throcal vertebra bodies were asymmetrical (Fig. 7), and they were wedge-shaped due to curvature (Fig. 8). T4 and T5 are fused and curved (Figs 9, 10). It was observed that the costa was fused with T6 (Figs. 11, 12). The transverse processes of the lumbar vertebrae are short (Fig. 13). It was observed that the sternum was also curved due to deformation (Fig. 14). Bone protrusions were observed on the necks of the costa (Figs 15, 16). Left femur is 33.2 cm, right femur is 33.6 cm. Both femurs are curved in the medial direction (Figs 21, 22, 23).

As a result of the computerized imaging technique, the bone density shows that the individual has osteoporosis. It is seen that the anatomical appearance of the distal end of the left femur is not in its normal position. It is seen that the anatomical appearance of the distal end of the left femur is not in its normal position (Fig. 23). Again with computed tomography, it is seen that the severity of scoliosis increases with the throcal vertebrae (Fig. 24).

Figure 7. Vertebral body asymmetry

Figure 8. Wedge-shaped vertebra

Figure 9. T4 and T5 vertebral fusion

Figure 10. T4 and T5 vertebral fusion

Figure 11. Costa and vertebral fusion

Figure 12. Costa and vertebral fusion

Figure 13. Transverse processes of lumbar vertebrae

Figure 14. Curvature in the sternum

Figure 15. Costae neck bony prominence due to arthritis

Figure 16. Deformed costae due to scoliosis

Figure 17. Pelvis of an individual with scoliosis

Figure 18. Right coxa (acetabulum)

Figure19. Left coxa (acetabulum)

Figure 20. Sacrum of an individual with scoliosis

Figure 21. Curvature of the right femur of an individual with scoliosis

Figure 22. Right femur and left femur

Fig 23. CT view of right and left femurs

Fig 24 . Photograph and CT image of the vertebrae of the individual with scoliosis

Table 3. Conditions observed in the skeleton (SBK19M24B1)

Cranium – Mandibula	There is little protic hyperostosis in the cribra orbitalia, frontal and occipital bones. Osteoarthritis has been observed in the condylar process of the mandible. All teeth in maxilla and mandible are antemortem.
Atlas	Normal
Axis	Normal
C 3	Asymmetry in vertebral body, osteophyte, asymmetry in articular facets
C 4	Asymmetry in vertebral body, osteophyte, asymmetry in articular facets
C 5	Asymmetry in vertebral body, osteophyte, asymmetry in articular facets
C 6	Asymmetry in vertebral body, osteophyte, asymmetry in articular facets
C 7	Asymmetry in vertebral body, osteophyte, asymmetry in articular facets
T 1	Vertebral body asymmetry, osteophyte, articular facet asymmetry, transverse process asymmetry, spinous process spinous and rightward deviation
T 2	Asymmetry in the vertebral body, fusion with the 3rd throcal vertebra, onset of scoliosis curvature
T 3	Asymmetry in the vertebral body, fusion with the 2nd throcal vertebra
T 4	Asymmetry in the vertebral body, osteophyte, deformation in the right articular facet, asymmetry in the right and last articular facets
T 5	Asymmetry in vertebral body, asymmetry in articular facets, fusion of right costae and 5th throcal vertebra
T 6	Vertebral body asymmetry, osteophyte, articular facet asymmetry, transverse process asymmetry, spinous process spinous and rightward deviation, osteoarthritis
T 7	Vertebral body asymmetry, osteophyte, articular facet asymmetry, transverse process asymmetry, spinous process spinous and rightward deviation, osteoarthritis
T 8	Vertebral body asymmetry, osteophyte, articular facet asymmetry, transverse process asymmetry, spinous process spinous and rightward deviation, osteoarthritis
T 9	-
T 10	-

T 11	Vertebral body asymmetry, osteophyte, articular facet asymmetry, transverse process asymmetry, spinous process spinous and rightward deviation, osteoarthritis
T 12	Vertebral body asymmetry, osteophyte, articular facet asymmetry, transverse process asymmetry, spinous process spinous and rightward deviation, osteoarthritis
L 1	Asymmetry in the vertebral body, osteophyte, osteoarthritis in the articular facets, shortening of the transverse process, process spinous short and blunt, osteoarthritis
L 2	Asymmetry in the vertebral body, osteophyte, osteoarthritis in the articular facets, shortening of the transverse process, process spinous short and blunt, osteoarthritis
L 3	Asymmetry in the vertebral body, osteophyte, osteoarthritis in the articular facets, shortening of the transverse process, process spinous short and blunt, osteoarthritis
L 4	Asymmetry in the vertebral body, osteophyte, osteoarthritis in the articular facets, shortening of the transverse process, process spinous short and blunt, osteoarthritis
L 5	Asymmetry in the vertebral body, osteophyte, osteoarthritis in the articular facets, shortening of the transverse process, process spinous short and blunt, osteoarthritis
Pelvis	Severe erosive deformation of the aericular surface of the right coxa, and erosive deformation of the acetabulum. It was observed that the aericular surface of the left coxa was severely, erosive deformation in the acetabulum and the femur re-seated in the acetabulum. Joint deformation in the left sacral tuberosity in the sacrum
Upper Extremity	Bone density decreased in the right and left humerus due to osteoporosis. Osteophyte in the olecranon processes of the right and left ulnas. Deformation of the distal radioulnar articular surface of the left ulna and styloid. Joint deformation in the process styloid of the left radius
Lower Extremity	Right and left femurs curved medially due to scoliosis, osteoporosis and osteomalacia. Condylus medialis and lateralis deformations in the left tibia
Costae, Sternum, Clavicula	There are bony prominences in the Costae rags and extremitas ventralis parts. Decreased bone density in the sternum due to osteoporosis, distal curvature in the left sternal manibrium due to scoliosis, 2. Costal notch distal shift in the left sternum. Deformation of the sternal and acromion ends of the clavicles

3. DISCUSSION CONCLUSION

Scoliosis is the lateral inclination of one or more vertebrae (Keim, 1972, Mann, 2005). Scoliosis can have many causes such as tuberculosis, osteoporosis, non-specific osteomyelitis, polio, trauma.

Idiopathic scoliosis, which constitutes more than 80% of the cases, is subdivided into infantile, juvenile, adolescent and adult. Paralytic scoliosis occurs as a result of the reduction of spinal muscles by neurological diseases. Scoliosis is seen in adolescence and especially in women over 65 years of age.

It is very difficult to detect the diseases seen in the vertebrae of ancient human remains. Kyphosis refers to an anterior curvature of the spine in the anteroposterior plane. It occurs especially as a result of diseases such as tuberculosis, osteomyelitis, brucellosis or fractures in the vertebrae with osteoporosis marital (Waldron, 2009). There is a relationship between scoliosis and Klippel-Feil syndrome. (Waldron, 2009). The 3 classic symptoms of Klippel-Feil Syndrome are short neck, backward hairline, and restricted neck movement. There are 3 types of fusion in Klippel-Feil syndrome, which is caused by genetic reasons and usually affects the cervical vertebrae. In Type II, especially in the 2nd and 3rd cervical vertebrae, involvement was observed in the 5th and 6th cervical vertebrae, as well as fusion in the T2 and T5 vertebrae. (Leggio et al., 2022).

Vertebrae must be complete or nearly complete in order to detect scoliosis in paleopathological studies. The vertebral bodies of an individual with scoliosis are asymmetrical. Articular facets are irregular, transverse processes and ribs are deformed.

The earliest example with scoliosis is the Paleolithic man from Combe-Capelle. According to Dastugue and Gervais (1992), this example showed a lateral trend in the sacral prominence, which is a clear sign of scoliosis. Ortner and Putschar (1985) described a specimen with scoliosis from the archaeological city of Hawikuh (New Mexico, U.S.A.). During the 1680

Pueblo revolt/uprising, the Spanish monk's skeletal combination showed mild deformity in his legs, possibly as a sign of ricket in early childhood, which was the cause of scoliosis and scoliosis (Aufderheide et al., 1998).

In Çatalhöyük, individual numbered SK 10314, dated to Byzantium, lived with structural scoliosis during his life. The vertebrae of the individual SK 10314 are wedge-shaped and asymmetrical. The absence of another pathological case indicates that this individual probably has Adolescent Idiopathic Scoliosis (Gosman et al., 2006).

In the sample from Gruczno in Poland, atrophy of the right lower extremity bones, coronal wedge shape and asymmetry in the vertebrae are associated with structural scoliosis. Asymmetry in the spine and atrophy in the leg are probably paralytic-related, secondary to poliomyelitis (Gosman et al., 2006).

17th-19th century in Sinop Balatlar Orthodox Church, Scoliosis was observed in the skeleton with the code SBK19M24B1, which was found to be a woman over 65 years old, which was found out of a Greek Orthodox grave dated to the 17th century. The body part of the vertebrae belonging to the individual is asymmetrical. The deviation in the spine started from the 2nd throcal vertebra and ended at the 6th throcal vertebra. The curvature occurred on the right side of the individual. It has been observed that osteoporosis and osteomalacia are also accompanied by diseases.

It is clear that a woman with scoliosis has difficulties in her daily life due to the physical problems she is exposed to. Not just posture defect, it is also thought that the individual suffers from muscle pain, joint diseases, limitation of movement and respiratory problems due to scoliosis. The fact that the individual with scoliosis lives until old age despite these adverse conditions shows that he is cared for by her family. The protection of the most prominent individual with scoliosis identified in ancient Anatolian societies by making use of osteoarchaeological data is also a proof of the socio-cultural development of the society. This case, which was described in Sinop Balatlar church, will set an example for future studies. It will also encourage anthropologists to focus their attention specifically on the vertebrae during excavation.

AUTHOR CONTRIBUTION

Mustafa Tolga Çırak: Excavation of the skeleton from the excavation area. Photographing in the field. Identification of pathology and establishment of methodology. Determination of age and gender. Writing the discussion and conclusion part (50%).
Emel Acar: Literature review. Performing osteometric analyzes of the skeleton. Photographing in the laboratory. Determination of age and gender. Writing body text (50%).

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Web Resources:

La Scoliosi & Postura https://www.osteopatastefanomassetti.it/la-scoliosi-postura/ (Access Date: 25.10.2022)
Scoliosis https://eorthopod.com/scoliosis/ (Erişim tarihi: 02.11.2022)
Scoliosis Research Society – SRS https://www.srs.org/ (Access Date: 17.02.2020)