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Abnormal thoracic vertebrae and the evolution of horse husbandry

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ABSTRACT: The question of the origin and evolution of horse husbandry is one of the most interesting and most disputed problems in history. This paper uses palaeopathology to explore this problem. Samples of equid thoracic vertebrae from 4 populations – free living Exmoor ponies, Early Iron Age Scytho-Siberian horses, Medieval Turkic horses and Eneolithic horses – are compared. Preliminary results suggest that the abnormalities of free-living horse caudal thoracic vertebrae differ from those of riding horses and most especially from those of horses ridden with pad saddles.

KEYWORDS: HORSE, PALAEOPATHOLOGY, THORACIC VERTEBRAE, ENEOLITHIC, SCYTHO-SIBERIAN, TURKIC

RESUMEN: La cuestión acerca del origen y evolución del caballo doméstico es uno de los problemas más interesantes y controvertidos de la historia. Este trabajo hace uso de la paleopatología para investigar el problema. En él se comparan muestras de vértebras torácicas de équidos procedentes de 4 poblaciones: poneys silvestres de Exmoor, caballos escito-siberianos de la Edad del Hierro inicial, caballos turcos medievales y caballos eneolíticos. Los resultados preliminares sugieren que las patologías de las vértebras torácicas caudales de los caballos silvestres difieren de los caballos de monta especialmente aquellos que cabalgan con sillas de cojín.

PALABRAS CLAVE: CABALLO, PALEOPATOLOGÍA, VÉRTEBRA TORÁCICA, ENEOLÍ-TICO, ESCITO-SIBERIANO, TURCO

INTRODUCTION

The centrality of the horse to human existence on the central Eurasian steppe throughout the Holocene is reflected by its virtual omnipresence in the cultural and economic life of steppe peoples. We can hypothesise that the evolving relationships between people and horses must have been crucial to the settlement of the steppe and to the development of pastoral societies. Moreover, once the horse began to play a significant role in transport and warfare both on the steppe and in adjacent regions, it seems most likely that it would have had an important impact on the development of social and political relations both within and between societies. However to prove this we would need to understand the evolution of human-horse relationships, and we do not. The origin of horse domestication and the evolution of horse husbandry are among the most intractable of archaeological questions.

Throughout the course of the 20th century a variety of theories have attempted to explain where, when and for what purposes the horse was first domesticated (Levine, 1999). In some situations it is, of course, very easy to show how horses had been used in ancient times. For example, the horses found in some of the south Siberian Early Iron Age kurgans (that is, burial mounds) were accompanied by well preserved equipment such as bridles, saddles and harnessing. However, at most sites, especially those dating from the period when horses were probably first domesticated, organic materials are only very rarely recoverable from the archaeological record. Moreover, not only it is possible to ride a horse without a saddle or bridle, but also, during the early stages of horse domestication, it is probable that they were usually ridden that way.

There can be little doubt that the best approach to the investigation of the evolution of horse husbandry is to employ as many analytical methods as are relevant – for example, population structure, taphonomy, osteometric analysis. One of the most promising approaches is the study of equid palaeopathology. The authors – an archaeologist and two veterinarians experienced in equine osseous pathology – have therefore been collaborating on an investigation of horse skeletal material from central Eurasian Early Iron Age and Medieval burials and Eneolithic settlement deposits and comparing them with skeletons of modern horses.

The results of this research, though still at an early stage, have been very promising. We are developing a methodology, which will enable us to learn more about the origins of horse domestication and the evolution of horse husbandry.

PALAEOPATHOLOGY AND HORSE HUSBANDRY

The basic premise underpinning this project is that the horse did not evolve in nature to carry a person on its back or to pull wagons and carriages. Until this project, very little systematic research had been published on this subject. However, a mixture of anecdotal evidence and empirical observations suggested that the kinds and, particularly, the incidences of abnormalities that we can expect to find in bones of wild horses differ from those in domesticated ones (Baker & Brothwell, 1980).

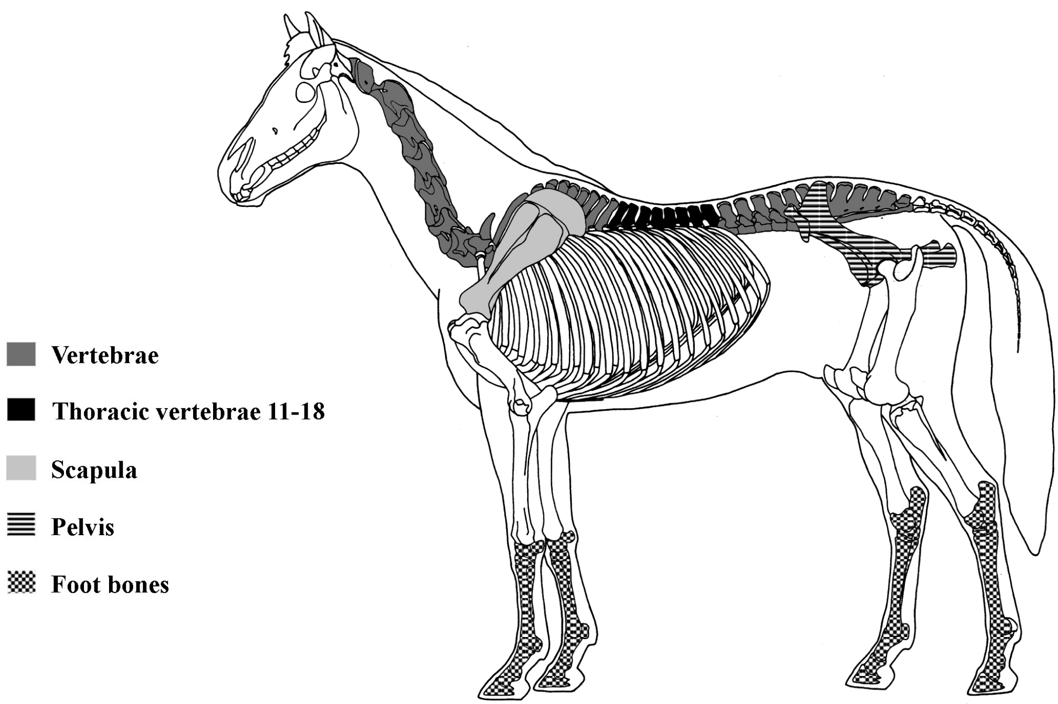

FIGURE 1
Horse skeleton with areas of special interest.

Approximate Dates (BC)	Period
900 – 300	Early Iron Age
1000 – 900	Transition to Early Iron Age
1800/1700 – 1200/1000	Late Bronze Age
2000/1900? – 1800/1700	Middle Bronze Age
3000/2900 (2750?) – 2300/1900?	Early Bronze Age (EBA)
3500/3400 – 3000/2900 (2750?)	Final Eneolithic – beginning of EBA
4800/4700? – 3500/3400	Eneolithic
6000 – 4800/4000	Neolithic

TABLE 1

Chronology of the west Eurasian Steppe. (According to Yuri Rassamakin, pers. comm.).

The stresses associated with riding and traction differ from those related to more natural activities. Furthermore, because the stresses connected with riding differ from those connected with traction, we would expect that if horses were used primarily for one or the other, this would also be reflected in their bones. This is not to say that all incidences of certain types of abnormalities will be referable to particular types of human-horse relationships. For example, it seems likely that some types of pathologies have a genetic component or are, at least partly, age and weight related (Bartosiewicz *et al*., 1997). The hypothesis to be tested here is not that any particular abnormality can have only one cause, but rather that working horses show higher frequencies of certain skeletal abnormalities than free living ones.

We are studying all equid skeletal elements, but four areas are of particular interest to us: the lower leg bones, hip, shoulder and backbone (Figure 1). However, the work to be discussed here deals only with abnormalities of the caudal thoracic vertebrae, mainly T11 to 18. This project compares bones of contemporary horses, whose history we know, and those of archaeological horses, whose history we can infer from their context, with the bones of animals whose history we would like to understand.

Two types of comparative material are discussed here:

1) The first type is skeletons from archaeological deposits where we feel confident about the horse's lifestyle. Throughout Eurasia, from the Bronze Age through the Middle Ages, horses were buried with or near human beings (Table 1). During the Bronze Age they were often buried with two-wheeled carts or chariots, while in the Iron Age they could be buried either with riding tack or with chariots (Gening *et al*., 1992; Littauer & Crouwel, 2002). In some places, particularly in the Altai, preservation has been excellent because of local environmental conditions. At sites located in the permafrost not only bones, but also flesh and artifacts made from perishable materials, associated with riding and traction, can be recovered (Barkova, 2000).
2) The second type of comparative material is contemporary free-living horses, in particular, Exmoor ponies. Comparison of skeletons of working horses with those of free-living ones should indicate whether unworked, unconfined animals have the same kinds and incidences of skeletal abnormalities as worked ones.

We have so far carried out detailed analyses of thoracic vertebrae of riding horses from four Early Iron Age Scytho-Siberian horse skeletons from Ak-Alakha 5 and two Medieval Turkic skeletons from Ak-Alakha 1 (Table 2). Both sites were excavated in 1995 by Dr. N. Polos'mak. Ak-Alakha 1 and Ak-Alakha 5 each comprise a group of kurgans (burial mounds) located in the valley of the Ak-Alakha river in the Ukok highland (Kosh-Agach District of the Altai Republic). The Ukok, situated in the southernmost part of the Altai Mountains, bordering China, Mongolia and Kazakhstan, is a flat, treeless plateau about 2500 metres above sea level (Figure 2; Polos'mak, 1994).

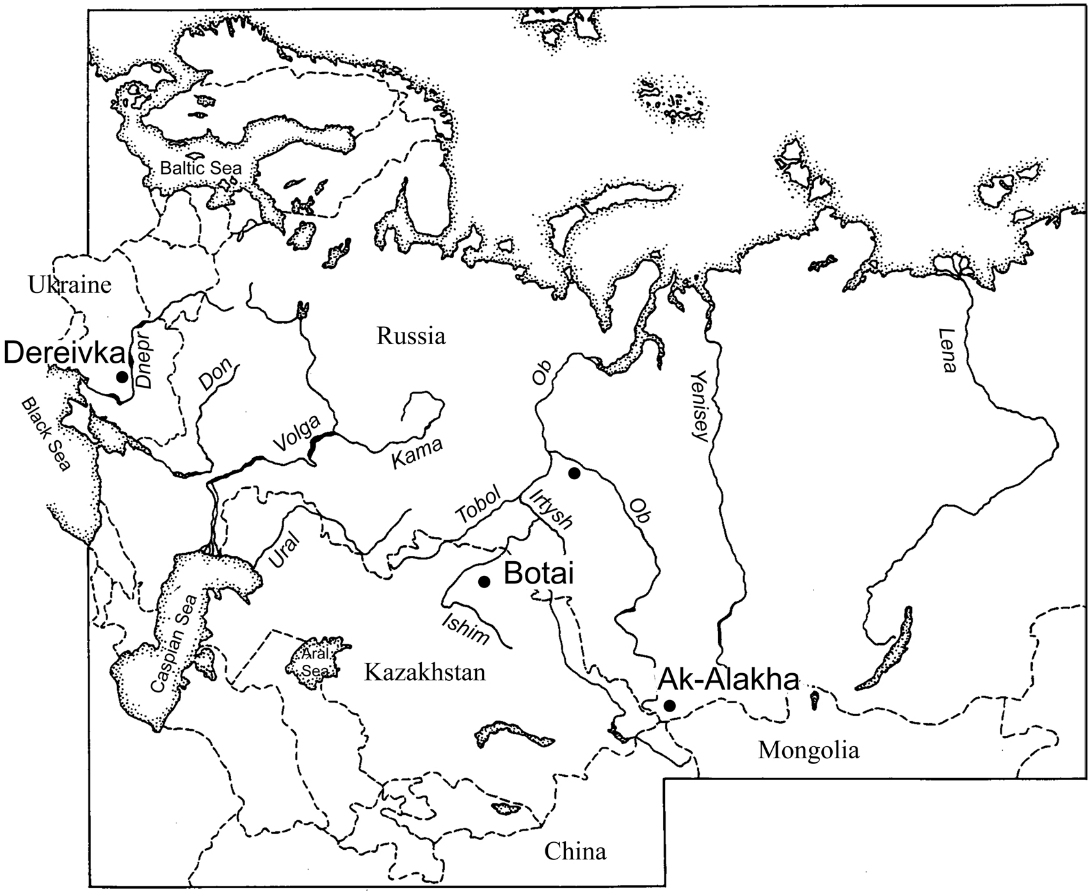

FIGURE 2
Map showing site locations.

Site	Location	Period	Horse id.	Age at death (yrs)[1]
Ak-Alakha 5, k3	Altai	Scythian (Early Iron Age)	1 2 3 4	16+ 10-15 10.5 7-10
Ak-Alakha 1, k3	Altai	Turkic (Medieval)	1 2	11 10.5
[1] Based uponincisor wear.				

TABLE 2
List of kurgan burial horse skeletons studied in this paper.

The Early Iron Age burials from Ak-Alakha 5 date from the 5th to the 3rd centuries BC. The four horses from Ak-Alakha 5, Kurgan 3, were buried on top of one another adjacent to a Pazyryk culture burial chamber (Figure 3). They were all wearing bits and there was no evidence of traction equipment, which suggests that they were riding horses. Soft tissue was not preserved at this site, but the

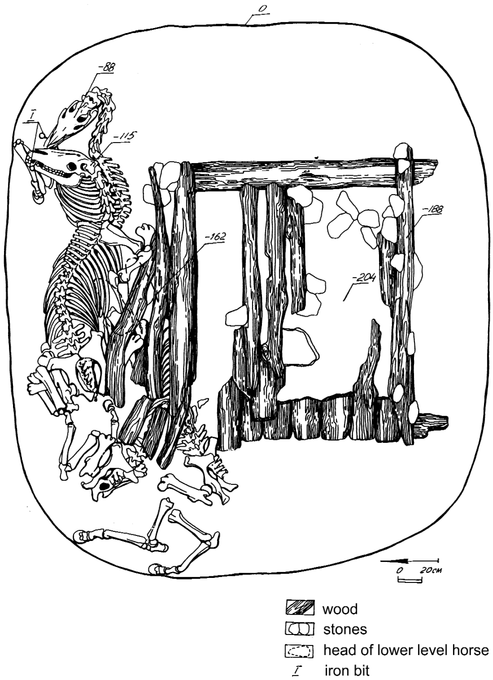

FIGURE 3

Plan of Pazyryk culture burial chamber, Ak-Alakha 5, Kurgan 3. Copyright © N. V. Polos'mak.

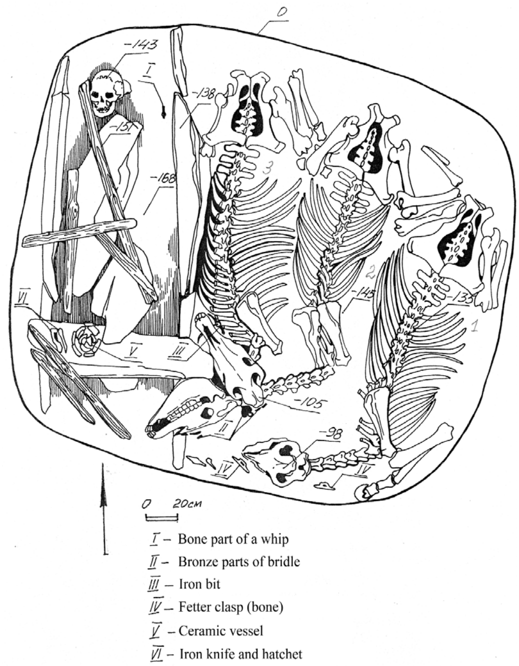

FIGURE 4

Medieval Turkic burial chamber, Ak-Alakha 1, Kurgan 3. Copyright © N. V. Polos'mak.

bones were in very good condition. The three Medieval Turkic horses from Ak-Alakha 1, Kurgan 3 (10th century AD), also well preserved, were buried side by side with riding tack, but unfortunately, because they were not frozen, the saddles were not preserved (Figure 4). Two of those horses are included in this study.

The caudal thoracic vertebrae (11-19) of both the Iron Age and Medieval horses from Ak-Alakha have several characteristics which suggest that these animals probably would have had a pony-like conformation:

1. Similar size to modern ponies.
2. Wide interspinous spaces.
3. Spatulate dorsal spinous processes.
4. The caudal borders of the summits of the spinous processes of T12-14 are hooked.

See, for example, Ak-Alakha 5, Kurgan 3, Horse 2, Thoracic vertebrae 11-19 (Figure 5). That the Early Iron Age, Medieval and Exmoor horses all have a pony-type conformation, should increase their comparability with one another.

Some of the caudal thoracic vertebrae from each of the Early Iron Age horses are pathological. Abnormalities of other areas of the skeleton are much less frequent and less regular in form. This paper will discuss a group of pathologies which have been observed on all four Early Iron Age horses. Interestingly these abnormalities are either absent from the Medieval Ak-Alakha and Exmoor ponies or relatively insignificant. What makes this complex of abnormalities particularly interesting is its possible implications for the history of horse riding. This work is only at a very preliminary stage, so these observations should be regarded not as conclusive, but rather as thought provoking.

EARLY IRON AGE HORSE SKELETONS FROM AK-ALAKHA 5, KURGAN 3

All four of these horses were found wearing bits. Although their bones were well preserved, burial conditions were not good enough for the survival of saddles. However, the context of the burials suggests that they were riding horses.

FIGURE 5
Ak-Alakha 5, Kurgan 3, Horse 2, thoracic vertebrae 11-19.

Significantly all four Early Iron Age horses have similar abnormalities of the caudal thoracic vertebrae (Figure 1). These abnormalities include:

(1) Deposition of spondylotic spurs of new bone on the ventral and lateral surfaces of the vertebral bodies adjacent to the intervertebral space. For example, Ak-Alakha 5, Kurgan 3, horse 4, thoracic vertebra 14 (Figure 6).
(2) Overriding or impinging dorsal spinous processes. For example, Ak-Alakha 5, Kurgan 3, Horse 1, thoracic vertebrae 14-18 and lumbar 1 (Figure 7).
(3) Horizontal fissures through the epiphyses. For example, Ak-Alakha 5, Kurgan 3, Horse 3, thoracic vertebra 14 (Figure 8).
(4) Periarticular osteophytes: the deposition of new bone on and above adjacent articular processes between vertebrae. For example, Ak-Alakha5, Kurgan 3, Horse 4, thoracic vertebra 16 (Figure 9).

Work has only just begun trying to understand the meaning of the pattern of abnormalities observed at Early Iron Age Ak-Alakha (Table 3). Pathologies related to 1), 2) and 4) have been rather frequently described in the veterinary and archaeological literature (for example, Bökönyi, 1968; Rooney, 1974, 1997; Baker & Brothwell, 1980; Jeffcott, 1980; Müller, 1985; Klide, 1989; and, for donkeys, Clutton-Brock, 1993). Rooney (1997) and Klide (1989) have demonstrated that lesions 1) and 2) are not just associated with domestic horses or even only with *Equus caballus*. Both are connected with natural ageing processes and with congenital defects. It is generally believed that riding also causes or contributes to their development (Jeffcott, 1999).

All the references relevant to lesion 3) found so far, have related to archaeological discoveries (Müller, 1985; Benecke, 1994; Lauwerier, pers. comm.). Müller and Benecke have both found this type of fissure on central European Medieval horses. Müller hypothesised that it could have occurred when a horse, wearing an ill-fitting saddle, was asked to jump. Benecke suggested that such an injury could have resulted when a horse was ridden too long and too hard.

A radiograph of the 14th thoracic vertebra of Ak-Alakha 5, Kurgan 3, Horse 4 (Figure 10) demonstrates that the fissure running through the frontal plane of the centrum does not penetrate into the spongy body of the vertebra, but is confined only to the denser bone of the caudal epiphysis. Each of the Ak-Alakha horses has two vertebrae with such fissures (Table 3).

We have explored this problem further by comparing the Early Iron Age horses from Ak-Alakha with both a sample of domesticated, but free-living,

FIGURE 6
Ak-Alakha 5, Kurgan 3, horse 4, thoracic vertebra 14.

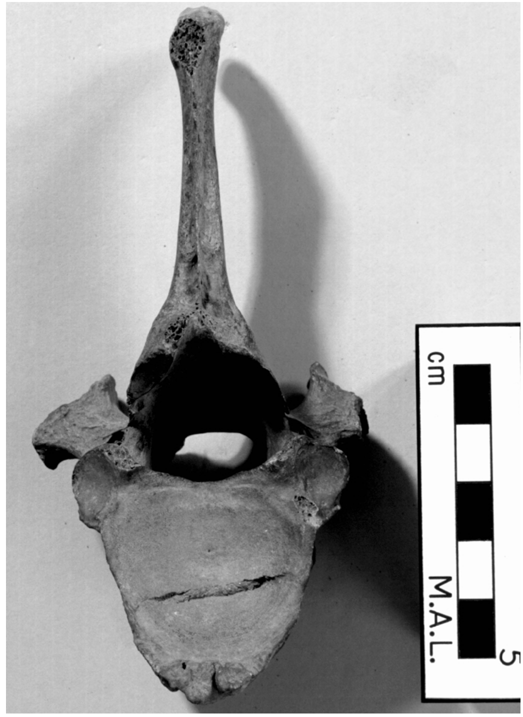

FIGURE 8
Ak-Alakha 5, Kurgan 3, Horse 3, thoracic vertebra 14.

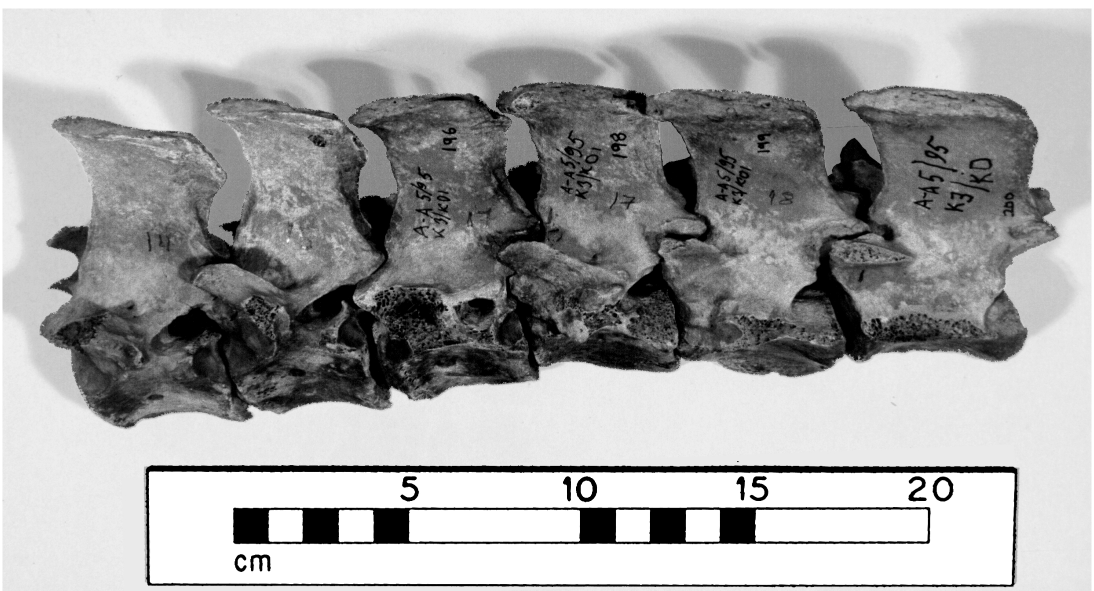

FIGURE 7
Ak-Alakha 5, Kurgan 3, Horse 1, thoracic vertebrae 14-18 and lumbar 1.

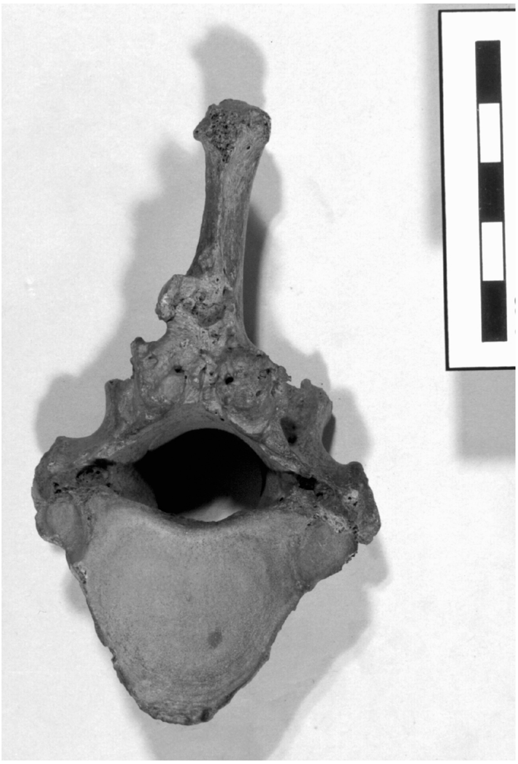

FIGURE 9

Ak-Alakha5, Kurgan 3, Horse 4, thoracic vertebra 16.

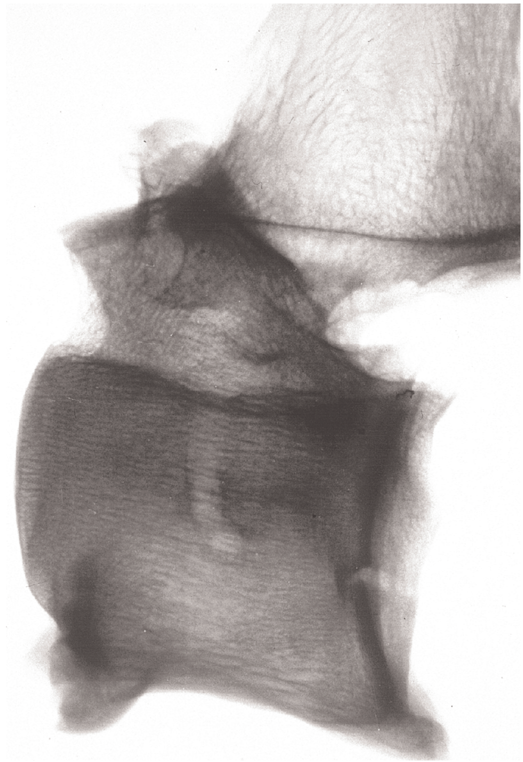

FIGURE 10

Ak-Alakha 5, Kurgan 3, Horse 4, thoracic vertebra 14. Radiograph showing epiphyseal fissure and spondylotic changes.

FIGURE 11

Exmoor pony 97-7 (27 years old), thoracic vertebrae 11-18.

	Ak-Alakha 5 (Altai)			
Horse number	1	2	3	4
Age (years)	16+	10-15	10	7-10
Sex	Male	Male	Male	Male (possible gelding)
Number of thoracic vertebrae	18	19	18	18
1) Osteophytes/spondylosis on the ventral and lateral surfaces of the vertebral bodies adjacent to the invertebral space	T11 to 18	Increasing from T11 to T14 (11 & 12 caudal; 13 & 14 caual + cranial	T14, 17, 18 strongly developed; T15 weakly developed	T13 to 15 most strongly developed, but extends to T17
2) Impinging or overriding spinous processes	T16 - 18 (oissubkt T15 also)	T14 - 15 probably; T15 - 19 possibly	Unclear because of poor preservation	T10 - 12 probably
3) Horizontal fissure through epiphysis	T13 and 15, caudal	T13 and 14, (most developed on T14), caudal	T14, caudal; T18, cranial	T13 and 14, (most developed on T14), caudal
4) Periarticular changes	T16 - 17 small osteophytes	T15 - 18 small osteophytes	T17, 18, small osteophytes	osteophytes, increasingly from T14 to T17, then decreasing[1]

[1] At T16-T17 and, to a lesser extent at T15-T16, these changes were pronounced and extended dorsally to involve the adjacent vertebral arches and lower regions of the spinous processes. This had not, however, resulted in the fusion of the vertebrae.

TABLE 3

Description of Thoracic Vertebrae 11-19 Abnormalities: Early Iron Age Horses.

unridden Exmoor ponies of various ages and with two Medieval horses from Ak-Alakha. So far only a relatively small number of animals have been examined in detail, but even at this very early stage, the investigations have yielded some interesting results and some new questions.

EXMOOR PONIES

Of the twelve Exmoor ponies collected, five are 10 years or older. All manifest a very similar pattern of abnormalities which we are illustrating in some detail here with two typical individuals (Table 4).

	Exmoor	
Horse number	97/2	97/7
Age (years)	12	27
Sex	Female	Female
Number of thoracic vertebrae	18	18
1) Osteophytes/spondylosis on the ventral and lateral surfaces of the vertebral bodies adjacent to the intervetebral space	Not present	Slightly developed, T12-14
2) Impinging or overriding spinous processes	Not present	Not present
3) Horizontal fissure through epiphysis	Not present	Not present
4) Periarticular changes	Not present	T11-18 small osteophyes

TABLE 4

Description of Thoracic Vertebrae 11-18 Abnormalities: Exmoor ponies.

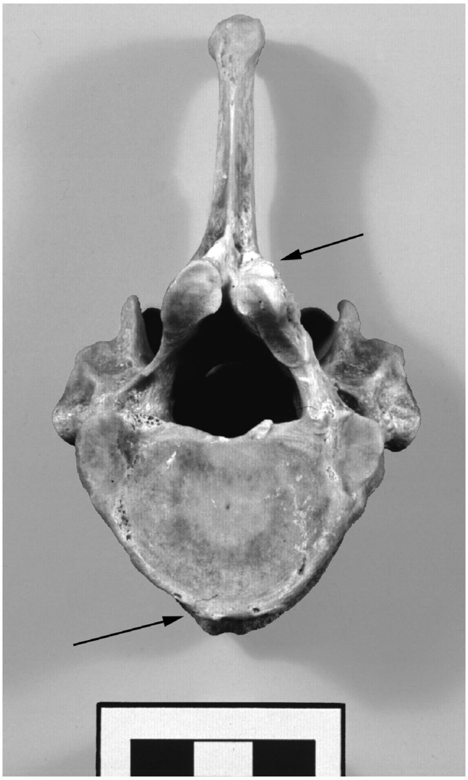

FIGURE 12

Exmoor pony 97-7 (27 years old), thoracic vertebra 14.

One was 27 (EP97/7) and the other 12 years old (EP97/2). They were both free-living and neither had ever been ridden. We decided to focus here on these older individuals because of the suggested connection between lesions 1) and 2) and the natural processes of ageing (Jeffcott, 1980; Townsend *et al*., 1986; Klide, 1989; Rooney, 1997). The data indicate that ageing processes are, either directly or indirectly, relevant to these abnormalities, but they do not entirely explain them.

The caudal thoracic vertebrae of the 12 year old pony have none of the lesions characteristic of the Early Iron Age Ak-Alakha horses. The 27 year old Exmoor has only two types of lesions: 1) weakly developed new bone on the ventral surface of a few centra, and 4) new bone on the articular processes of thoracic vertebrae 11 to 18 (Figure 11; Figure 12). The latter is more widespread than on the Iron Age horses, but less intense than on Ak-Alakha 5, Kurgan 3, Horse 4, which was only 7 to 10 years old (Figure 13 and Figure 9).

Ageing is important because over time the effects of all kinds of injuries and irregularities tend to be cumulative. The agents of vertebral damage, whatever they are, will have had less opportunity to develop in young animals. However, the evidence of the Exmoors indicates that the development of these pathologies is not inevitable.

FIGURE 13

Ak-Alakha 5, Kurgan 3, Horse 4, thoracic vertebrae 13-18.

	Ak-Alakha 1 (Altai)	
Horse number	1	2
Age (years)	11 years	10.5 years
Sex	male	male
Number of thoracic vertebrae	18	18
1) Osteophytes/spondylosis on the ventral and lateral surfaces of the vertebral bodies adjacent to the intervetebral space	T14, small ventral spondylotic spur	Not present
2) Impinging or overriding spinous processes	Spines crowded together and T13-16 have been touching, no significant overriding	Not present
3) Horizontal fissure through epiphysis	Not present	Not present
4) Periarticular changes	Slight erosion and pitting of articular facets between T14 & 15, T15 & 16, T17 & 18	Some fairly insignificant bony thickening on the processes between T13 & T14, T14 & T15

TABLE 5

Description of Thoracic Vertebrae 11-18 Abnormalities: Medieval Turkic Horses.

SCYTHIAN SADDLES

Assuming (at least for the time being) that the high incidences of pathological changes in the Scythian caudal thoracic vertebrae were significant, stress caused by riding would seem to be an obvious explanation for the apparent ubiquity of lesions 1), 2) and 4) in Scythian burials (Table 3). However, lesion 3), present in all four horses from Kurgan 3 (as well as in an Early Iron Age horse from the Ukrainian site of Lisovichi) seems to get little attention in the veterinary literature. The fact that ordinary radiographs of a horse would not show this lesion might at least partly explain this apparent omission. However, it would also be worth exploring the possibility that the high incidences of this lesion in Scytho-Siberian horses could be related not just to the fact that they were ridden but also to the way they were ridden.

The excellent preservation conditions and rich grave goods accompanying Scythian burials have provided us with a unique insight into contemporaneous riding equipment. One factor which might be of particular relevance to the pathologies discussed here is the Scytho-Siberian saddle. The Pazyryk culture saddles recovered so far – for example, from Ak-Alakha 1 and 3, Pazyryk and Bashadar – have all been pad saddles: variations on a theme of two leather cushions, stuffed with sedges or hair, joined together by an unpadded strip of leather (which rests over the horse's spine) and covered with felt (Figure 14; Polos'mak 1994, p. 45). Some of the saddles have high arches, reinforced with wooden spacers, at the 'pommel' and 'cantle'. They are regarded by Rudenko as the first step in the evolution of the frame saddle (Figure 15; Rudenko, 1970, pp. 130).

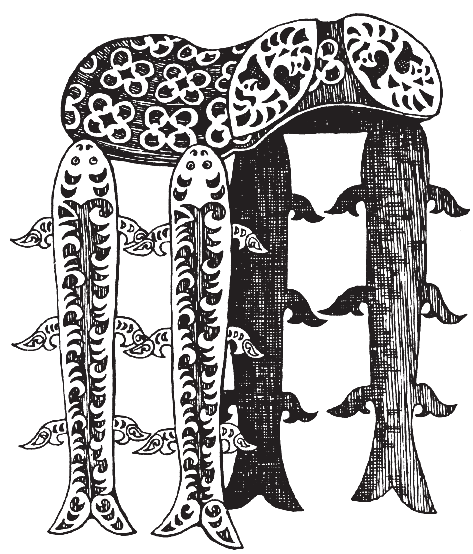

FIGURE 14

Reconstruction of a pad saddle from Ak-Alakha 1, Kurgan 1 (Polos'mak, 1994, p. 45). Copyright © 1994 N. V. Polos'mak.

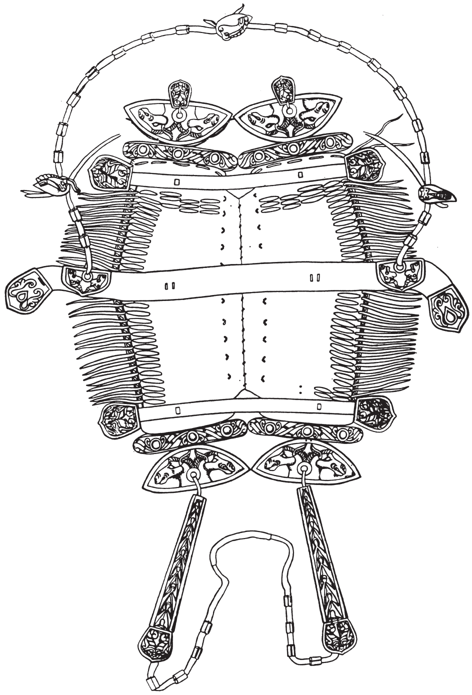

FIGURE 15

Reconstruction of pad saddle from Pazyryk, Barrow 5, viewed from above (Rudenko, 1970, p. 130). Copyright © J. M. Dent and Sons.

Although distributed to some extent over the dorsal rib cage by the saddle cushions, with a pad saddle the riders weight rests, in a large degree, directly on the dorsal spinous processes of the thoracic vertebrae (Figure 1). It is hypothesised here that the use of such saddles, by irritating the dorsal processes of the vertebrae, stressing the vertebral bodies and increasing the lordosis of the spine, could have been an important factor in the development of the lesions on the Ak-Alakha horses.

The early Iron Age peoples of the Altai were not the only ones to put horses in their graves. The Medieval Turkic peoples, who used saddles with wooden frames, did so as well and, like their Iron Age predecessors, they buried their horses with riding equipment (Figure 16; Margulan, 1994, p. 98; Molodin, 1994; Chemiakina and Polos'mak, pers. comm.). In contrast to the Scythian pad saddle, the frame saddle, when properly fitted, has no contact with the thoracic vertebrae. It distributes the riders weight entirely on the horse's dorsal rib cage. In that case, we should expect these horses to have a different pattern of abnormalities than those ridden with pad saddles. It should thus be possible to test the pad saddle hypothesis further by comparing Early Iron Age and Medieval skeletons from Ak-Alakha. We have, indeed, started to do

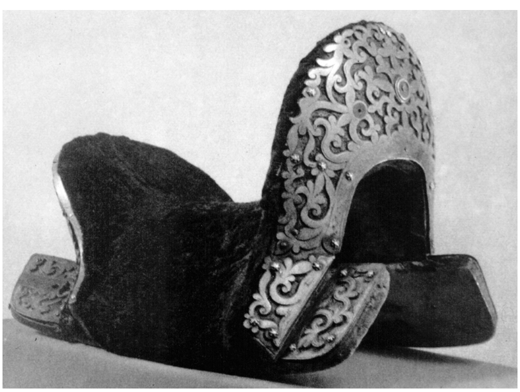

FIGURE 16

Traditional Kazakh frame saddle (Margulan, 1994, p. 98). Copyright © '*GHEP*' ['*Öner*'] Publishing House.

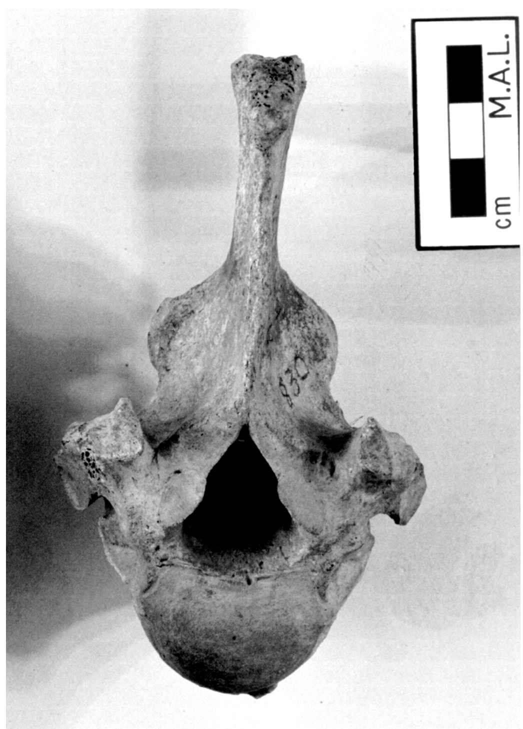

FIGURE 17

Ak-Alakha 1, Kurgan 3, Horse 1 thoracic vertebra 14.

FIGURE 18
Ak-Alakha 1, Kurgan 3, Horse 1 thoracic vertebrae 11-18.

this. The two Medieval horses from Ak-Alakha 1, Kurgan 3 (dated to the 10th century AD), were buried with riding tack, but unfortunately, because they were not in permafrost, the saddles were not preserved. However, information from other burials suggests that it is likely that frame saddles would have been used. Interestingly, the pattern of thoracic vertebral abnormalities in the Medieval horses, which are both approximately 10-11 years old, is very different from that of the Early Iron Age material investigated so far (compare Tables 3 and 5).

Abnormality 1 - Deposition of spurs of new bone on the ventral and lateral surfaces of the vertebral bodies adjacent to the intervertebral space. In horse 1 this type of lesion is only represented by a small spondylotic spur on one vertebra (the 14th thoracic) and it is absent from horse 2 (Figures 17 and 18).

Abnormality 2 - Impinging or overriding spinous processes. Thoracic vertebrae 13-16 were touching, but not overriding in horse 1. In horse 2 this abnormality was not present (Figure 19).

Abnormality 3 - Horizontal fissures through epiphyses. This abnormality is entirely absent from both horses 1 and 2.

Abnormality 4 - Periarticular osteophytes are not present in either horse 1 or 2. However, some of the vertebrae of both horses have mild periarticular abnormalities. In horse 1 there is a slight erosion and pitting of the opposing articular facets from thoracic vertebrae 14 to 18. The most pronounced changes are to the caudal articulations of thoracic vertebrae 17 and 18 (Figure 20). In horse 2 there is some rather insignificant bony thickening on the cranial articular processes of T13 to T15 (Figure 21).

It is highly unlikely that any of the changes to these Medieval vertebrae would have been of any clinical consequence. None of the abnormalities from the Medieval horses were as pronounced as those of the Early Iron Age horses. Indeed, the abnormalities of the Medieval horses are more similar to those of the Exmoors than to those of the Iron Age horses. Of course, it would be foolhardy to draw firm conclusions from our sample of two Medieval horses.

If these very preliminary results were representative, we might hypothesise that the caudal thoracic vertebrae of horses ridden with pad saddles or bareback should frequently show evidence of the kind of abnormalities manifested by the Ak-Alakha Iron Age horses. Obviously much larger samples are still needed to test this hypothesis.

FIGURE 19

Ak-Alakha 1, Kurgan 3, Horse 2, thoracic vertebrae 18-12.

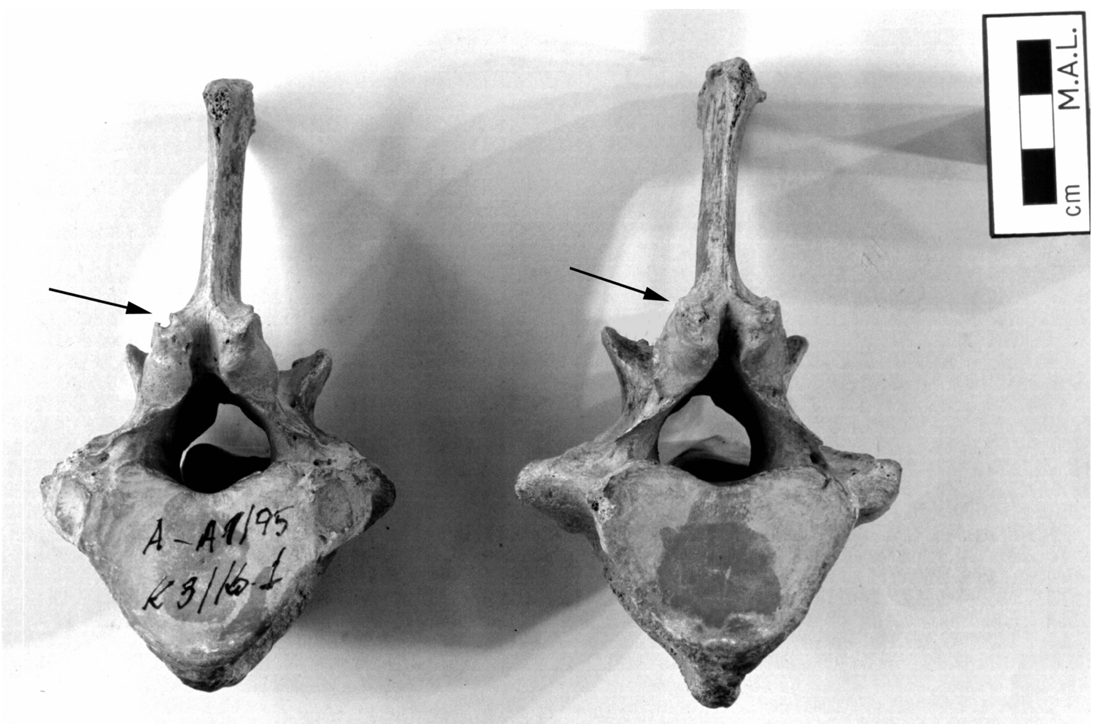

FIGURE 20

Ak-Alakha 1, Kurgan 3, Horse 1 thoracic vertebrae 17 & 18.

FIGURE 21
Ak-Alakha 1, Kurgan 3, Horse 2, thoracic vertebrae 14 & 15.

COMPARISON WITH ENEOLITHIC SITES

In the meantime, it is interesting to compare the incidences and severity of caudal thoracic vertebral abnormalities in Early Iron Age and Medieval horses and Exmoor ponies with their incidences and severity in Eneolithic horses, such as those from Dereivka and Botai (Figure 2), which are at the centre of debates concerning the origins of horse domestication (Levine *et al*., 1999).

Unfortunately, almost all the vertebrae from Dereivka were discarded after excavation without being studied. However, many vertebrae – including some in anatomical connection – were recovered at Botai, a settlement site dated to around 3500 BC. We have so far only examined a relatively small number (that is, 41) of caudal thoracic vertebrae (T11-18) from Botai which were complete enough to be relevant for this study. Only two from one horse showed signs of any abnormality and even that was only very slight, well within the range of the Exmoor Ponies (Figure 22). Virtually all the damage to the vertebrae was post-mortem.

DISCUSSION

Considering the enormous sample of material from Botai awaiting study, this conclusion must be regarded as extremely tentative. Taken together with the overall very low proportion of pathological bone at this site, the indications so far support the results of the population structure analysis, which indicated that the material from Botai examined so far most probably was from wild individuals (Levine *et al*., 1999).

Of course, both the archaeological and modern samples under consideration here are very small, but the results are promising. We intend to increase the sample sizes of all categories of data used in this study. An analysis of horses from chariot burials and a saddle pressure study are also planned.

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FIGURE 22

Botai adjacent caudal thoracic vertebrae (within the range T11-15).

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