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Manufacture and Use of Bone Tools in Neolithic Societies: Bone Tools from the Posht-e Forudgah Malayer Mound

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Abstract

The Posht-e Forudgah Malayer mound, located on the Malayer Plain in the Central Zagros, represents semi-nomadic communities whose subsistence economy during the Late Neolithic was based primarily on pastoralism. In this period, the integration of agricultural and herding practices encouraged the expansion and diversification of tools crafted from stone and, notably, from animal bone. Bone's flexibility, workability, strength, and accessibility made it a crucial raw material in Neolithic daily life. This study examines a small assemblage of bone tools of varied sizes, morphologies, and functions recovered from Posht-e Forudgah. A descriptive-analytical and comparative approach was undertaken, juxtaposing these artifacts with assemblages from other Late Neolithic sites in the Central Zagros. The research addresses three questions: 1) What morphological and functional characteristics do the Posht-e Forudgah bone tools exhibit? 2) Based on structural features, what roles did they have in the lives of nomadic or semi-nomadic communities? 3) Do they show structural or functional affinities with tools from contemporary, horizon-sharing sites? The objectives include analyzing morphology, investigating the toolmakers' technological skills, and assessing probable functions supported by experimental archaeological studies. The findings indicate predominantly conical-bodied, pointed, and polished tools, with wear traces revealing repeated use. Such patterns suggest specialized production, informed by accurate knowledge of bone properties and by a technological system embedded in the dynamic social structure of Late Neolithic semi-nomadic pastoralists. By studying these tools, the research contributes to reconstructing aspects of subsistence, offering insight into social organization, and deepening understanding of bone implement manufacture and uses—especially awls and needles—within nomadic Neolithic societies.

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1. Introduction

In the Neolithic period, with the consolidation of agricultural and pastoral subsistence patterns, remarkable transformations took place in the technologies required for daily life, including the manufacture of tools. Among these, the production of tools from animal bones due to their ready availability, high malleability, and relative durability was widely adopted in the everyday activities of human communities. The study of such materials, when approached in conjunction with archaeological research, yields more effective results when the cultural contexts of different regions can be compared. This comparative method was first employed by Robert Braidwood at the prehistoric site of Jarmo in Mesopotamia (Braidwood & Braidwood, 1950; Braidwood *et al.,* 1983). From a broader perspective, examining the cultural remains of various historical periods allows scholars to identify the differences, similarities, and unique attributes of artifacts. Thus, by studying bone tools in nomadic and semi-sedentary communities whose economies were based on pastoralism in the Central Zagros, and by comparing these with ethnographic data from traditional pastoral nomads today, it is possible to gather relatively substantial information. The Central Zagros, as one of the key regions in the emergence and development of Neolithic cultures, encompasses numerous sites such as Tepe Asiab (Braidwood, 1960), Sarab (Braidwood *et al.,* 1961), Guran (Mortensen, 1964), Abdul-Hossein (Pullar, 1990), Ganj Dareh (Young & Smith, 1966), East Chia Sabz (Darabi, 2014), Chogha-Golan (Zeidi *et al.,* 2012), Sheikh-e Abad (Matthews *et al.,* 2008; Mohammadifar *et al.,* 2011), Qalā Gāp (Abdullahi & Sardari Zarchi, 2013; Abdullahi *et al.,* 2014), Qeshlaq (Motarjem & Sharifi, 2018; Dehghan & Motarjem, 2024), and others. Through the study of faunal remains, these sites have yielded valuable insights into both the species exploited and the bone tools themselves. Also, the book The Neolithisation of Iran: The Formation of New Societies, edited by Hassan Fazeli and Roger Matthews (Fazeli-Nashli & Matthews, 2013), provides the most comprehensive account of the Neolithic period in Iran and the processes through which ideas, technologies, and plant and animal species were transmitted between the Near East, the Indian subcontinent, and Central Asia. The volume pays particular attention to key archaeological sites such as Abdul-Hossein, Ganj Dareh, Tepe Sarab, and Hajji Firuz, offering substantial data and insights that enrich and complement previous research.

Another notable site in this region whose role in the later Neolithic cannot be overlooked is the Posht-e Forudgah Malayer mound (Hamedan Province). Among the archaeological finds from this site is a diverse and noteworthy assemblage of bone tools, which is the focus of this study. The investigation of Neolithic bone tools holds importance from several perspectives, as these artifacts provide access to the social, cultural, and economic behaviors of the period. While stone tools, due to their durability, have long been a prime focus of archaeological attention and, in some cases, have even served as the basis for naming and defining entire Neolithic cultures based on their manufacturing techniques (e.g., Zarzian, Khiamian, Moulafatian lithic industries), bone tools have received comparatively little scholarly focus. The manufacture of these tools in the Neolithic reflects aspects of division of labor, technical skill, domestic usage, crafts, and even hunting practices. The semi-nomadic Posht-e Forudgah community, relying on

pastoral subsistence, offers a unique context for the specialized study of such tools. Although the assemblage is small, it exhibits a notable diversity in size and form. Through careful examination of the bone tools from this site, alongside comparative analysis with other contemporaneous sites and shared cultural horizons, we can address significant research questions concerning the reconstruction of cultural and technological behaviors in human communities of the late 6th and throughout the 5th millennium BCE. This is of considerable relevance not only to archaeology, but also to zooarchaeology, ethnoarchaeology, and bio-archaeology.

Research Questions and Hypotheses: The first question posed in this study is: What morphological and functional characteristics do the bone tools recovered from the Posht-e Forudgah Malayer site possess? The second question asks: Given the structure of these tools, what role did they play in the daily life of nomadic communities, and for what purposes were they used? The final question investigates: Do the bone tools from this site share structural and functional similarities with those from other contemporaneous and horizon-sharing sites? Considering the semi-sedentary and nomadic lifestyle of the region's inhabitants, the bone tools recovered from Posht-e Forudgah appear to have been intentionally designed in accordance with the subsistence needs of the community. This is evident through a specialized morphological examination of the tools, including their applications in handicrafts and everyday activities. In light of the numerous "Spindle Whorls" also retrieved from the site, it may be inferred that these tools were used in sewing, weaving, and, likely, in leatherworking, basketry, mat-making, as well as for incising designs on pottery in ceramic production. Furthermore, when compared with similar examples from other contemporaneous sites, these tools exhibit numerous morphological, structural, and functional commonalities. Ultimately, drawing on experimental archaeological studies conducted in the research area, the use of analogous bone implements especially awls and needles suggests their involvement in activities such as pottery decoration, sewing, weaving, basketry, mat-weaving, and leather-related crafts.

Research Methodology: This study is based on excavation data obtained from the Posht-e Forudgah site, complemented by library-based research grounded in a comparative and descriptive–analytical approach. In addition, for the interpretation of data, the research draws upon the theoretical foundations of ethnoarchaeology, employing ethnologic analogies to analyze the finds under investigation (Asher, 1961; Kramer, 1982; Watson, 1979; David & Kramer, 2001). The present study is organized into six sections. Following the introduction, the second section reviews the research background. Section three and four presents the theoretical framework, while section five discusses the study population, functional aspects, and research findings. The final section is devoted to experimental analyses and overall conclusions.

2. Background

Studies in human and animal osteology are among the core subjects of archaeology worldwide, and numerous books and scholarly resources have been written on the topic. Through osteological studies, a variety of analyses can be conducted, producing data relevant to both archaeological

and interdisciplinary research. Examples include The Archaeology of Human Bones (Mays, 2002), Zooarchaeology (Reitz & Wing, 2015), and Human Osteology in Archaeology (Hashemi & Vahdati-Nasab, 2023). It is evident that in archaeological studies, especially in prehistoric contexts, human and animal bones consistently constitute a significant portion of the recovered assemblages. Among animal bones in particular, many have been utilized for various purposes, such as tool-making or the production of decorative objects, with bone tools, especially awls and needles, being of primary importance. Given their abundance in prehistoric contexts, bone tools serve as valuable indicators for investigating the economic, social, and subsistence dimensions of past communities. Nevertheless, focused and specialized studies on this subject remain somewhat limited. A review of available sources shows that bone tools have often been merely cataloged or introduced, without being subjected to detailed analytical study.

Bone tools from the Ali Tepe (El-Tepe) in the eastern Alborz, dating to the transitional period between the Paleolithic and the beginning of the Holocene, are currently preserved in the National Museum of Iran (Manca *et al.,* 2018: 143). At the East Chia Sabz site, attributed to the Neolithic period, several decorative items and bone tools made from goat bone were identified, with one end sharpened for functional use (Darabi, 2014; Darabi *et al.,* 2011: 262). Similarly, at the Pre-Pottery Neolithic site of Sheikh-e Abad, excavated through collaboration between Iranian and British archaeological teams led by Yaghoub Mohammadifar and Roger Matthews, numerous bone artifacts, including polishers, awls, and needles, were recovered, some of which contained perforations likely intended for use (Mohammadifar *et al.,* 1390: 21; Matthews *et al.,* 2008). In Chogha-Golan, belonging to the transitional Neolithic, six engraved bone tools with shallow perforations, probably for decorative purposes, were found (Darabi *et al.,* 2024: 61). From Tepe Sang-e Chakhmaq in eastern Iran, numerous bone tools were also recovered; while initial studies merely noted their presence (Roustaei *et al.,* 2015: 589), a comparative study between the sites of Abdul-Hosein and Tepe Sang-e Chakhmaq was later conducted (Manca *et al.,* 2021: 27–42). This latter research examined bone tools from these sites held in the National Museum, utilizing morphological analysis to document methods of splitting and breaking bones for tool production, and to highlight their application in subsistence activities such as hunting, sewing, and farming insights that have also significantly contributed to the present study. At the Cham Qoleh site, associated with the village-based period in the Simerreh region, findings consisted mainly of large animal remains, attesting to the role of domesticated species such as goats, sheep, and cattle in the bio-economy of these communities (Moqaddam *et al.,* 1394: 61–62, Fig. 3).

In later periods, such as the Chalcolithic, bone tools from multiple sites have been documented. A complete set of Chalcolithic bone tools, including awls, needles, polishers, and arrowheads, has been reported from Chogha Mish (Delougaz & Kantor, 1996: Pl. 128). Another example, Tepe Qeshlaq, has been the subject of a zooarchaeological study that also briefly addressed the bone tools from Level V (Layers 3 and 4), comparing them to similar examples from Dalma, Hajji Firuz, and Jarmo (Sharifi, 2020: 333; Dehghan & Motarjem, 2024: 105). A case study of Tepe Gerd Ashvan in the Lesser Zab basin mentioned noteworthy bone tools from the Late Chalcolithic, alongside

analysis of faunal remains (Sharifi & Salimi, 2023: 116, Fig. 18). In the Qal'eh Bala site of Bijar, examples of bones used in tool production have also been introduced (Ash'ari, 2021: 30). Bone awls and needles from Section VIII of Doushan Tepe in Ozbaki are further notable, reflecting both hunting and herding practices in the Savojbolagh plain from the 6th millennium BCE to the Iron Age (Mashkour & Mohaseb, 2010: 280). Studies of bone arrowheads from Ziwiyeh have examined their functional and developmental trajectory from hunting implements to decorative tools in the Iron Age through both independent and comparative analyses (Hassanzadeh & Mashkour, 2023).

In summary, despite the recovery of bone tools from various historical periods and their evident importance as highly functional implements in human societies, relatively few have been studied in detail from the perspective of morphometric analysis, functional interpretation, and manufacturing techniques. The present authors aim to place the available published information on bone artifacts alongside the results from the semi-nomadic community of the Posht-e Forudgah site. In doing so, they seek to present a relatively comprehensive picture of bone tools, especially awls and needles supported by taking advantage of analogies from other contemporaneous and horizon-related sites, representing communities that, either unconsciously or deliberately, incorporated bone tools into their daily lives.

3. Review of Examples of Animal Remains Tools (Teeth and Bone)

The earliest examples of animal remains used as decorative pendants and possibly with a perforating function come from the Late Neanderthal period (33,000–30,000 years ago) at Arcy-sur-Cure, France (Fig. 1). Among the various examples of bone tools bearing engravings and decorative elements are those from the Magdalenian period (Fig. 2) as well as another example used in combination with stone (Fig. 3). In this regard, a prominent case is a Natufian sickle with flint blades for harvesting, made of gazelle horn with inserted flint blades; in some cases, wood was used instead of bone (Lewis *et al.,* 2012: 337, Fig. 13–21), (Fig. 4).

Fig. 1. Left: Decorative pendants made from animal bone and teeth for necklace production [possibly with perforating function?], from the Neanderthals (33,000–30,000 years ago), excavated at Arcy-sur-Cure, France. Right: (©Wade, 2016).

It is worth noting that examples of animal-remain tools made of teeth and bone are also known in Iran, with an age of approximately 40,000 years. Yafteh Cave is among the important Upper Paleolithic caves, belonging to the period 24,000–33,000 years BP based on radiocarbon dating. In the second season of excavation at this cave, conducted in 2005 by Marcel Otte and Fereidoun

Fig. 2: Bone tools from the Magdalenian period (© 2002 The Weinworth Group, division of Thomson Learning).

Fig. 3: Reconstruction of a Natufian sickle with flint blades for harvesting, made of gazelle horn with flint inserts (© 2002 The Weinworth Group, division of Thomson Learning).

Fig. 4: Example of a wooden sickle with flint blades (© Lewis *et al.*, 2012: 337, Fig. 13–21).

Biglari, alongside Aurignacian-type lithic tools, a bone awl and a perforator were recovered (Otte *et al.,* 2007, after: Vahdati-Nasab & Ariamanesh, 2015: 298). This bone tool can be considered among the oldest identified examples of bone awls in Iran to date (Fig. 5).

Fig. 5: Bone tool (awl) from Yafteh Cave, Upper Paleolithic (Otte *et al.*, 2007, after: Vahdati-Nasab & Ariamanesh, 2015: 300, Fig. 5–18).

Another example is the bone tools from the Ali Tepe site, located within the cultural sphere of northeastern Iran. This site was excavated by Charles McBurney in 1964 (McBurney, 1968). From the deposits of El-Tepe, 12 bone needle tools were recovered: 11 from Layers I to III (dating to 12,458–11,855 years ago) and one from Layers 22–23 (dating to 10,812–10,972 years ago), (Fig. 6). These needles, in terms of appearance and size, are similar to needle finds from Solutrean and Magdalenian sites in France and Upper Paleolithic sites in Russia, such as Kostenki, Mezine, and Gagarino, but show minor differences. At the time of discovery, they were the first of their type in the Paleolithic or Mesolithic of Iran and Iraq, and very different from Neolithic needles such as those from Belt and Hotu Caves. The Ali Tepe needles are long and slender, closely resembling examples from the European Upper Paleolithic (McBurney, 1968, after: Vahdati-Nasab & Ariamanesh, 2015: 395–397).

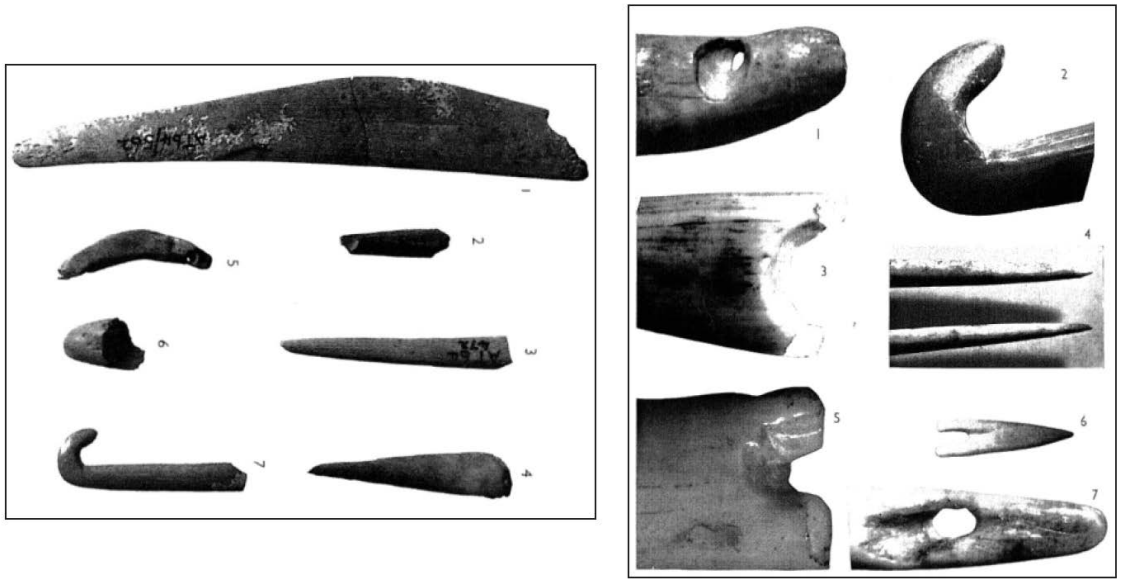

Fig. 6: Bone and worked needles from Ali Tepe (El-Tepe), (Fig. 6: Bone and worked needles from Ali Tepe (El-Tepe), (McBurney, 1968, after: Vahdati-Nasab & Ariamanesh, 2015: 396, Fig. 32–6).

Belt Cave and Hotu Cave, the other prominent cave sites situated along the southeastern coast of the Caspian Sea-Iran, date to around 15,000 years ago, on the eve of the Neolithic. These sites, excavated in 1949 and 1951 by Carleton Coon, were reexamined in 2021 by Hassan Fazeli-Nashli (Fazeli-Nashli *et al.,* 2024: 7, 21). From the Neolithic layers of Belt Cave, objects such as bone awls and a bone needle were recovered by Coon (Fig. 7). In the 2021 season, however, only three Canid teeth were recovered, which had been polished and perforated at one end for suspension. According to the excavation director—and given that a complete necklace of such teeth was found on the burial of an infant in Hotu Cave—these are likely to have been used as neck pendants by Mesolithic communities (Fig. 8). Such tooth pendants appear to represent a shared cultural trait among these groups and were previously published by Coon from Belt Cave (Coon, 1951: 115) and by McBurney from Ali-Tepe (McBurney, 1968; Manca *et al.,* 2018). Two similar examples were recovered from Kamishani Cave (Fig. 9) by Hamed Vahdati Nasab, who assigns them to c. 10,628 BP (Vahdati Nasab *et al.,* 2020: 114; cited in: Fazeli-Nashli *et al.,* 2024:

30–31). In the 2023 excavation season led by Hassan Fazeli-Nashli, several additional examples of such pendants were recovered from Kamishani Cave (Fazeli-Nashli, 2023). In addition to Belt Cave, from Hotu Cave in the 2021 reexamination, three bone awls were identified and presented, similar in form and function to the bone tools of Belt Cave (Fazeli-Nashli *et al.,* 2024: 21, Fig. 18), (Fig. 10).

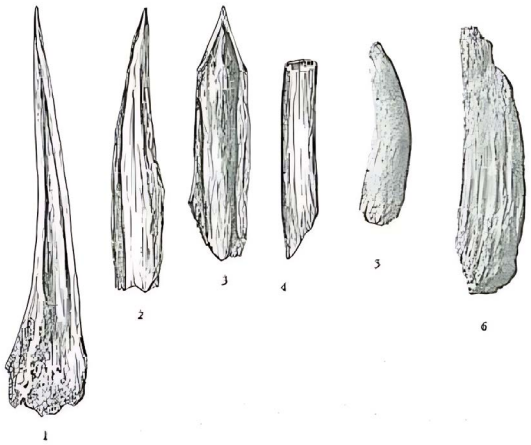

Fig. 7: Bone tools from Belt Cave (Coon, 1949, after: Vahdati-Nasab & Ariamanesh, 2015: 383, Fig. 24–6).

Fig. 8: Example of pendants with wolf teeth from Belt Cave (Fazeli-Nashli *et al.,* 2024: 30, Fig. 16).

Fig. 9: Decorative tooth from Kamishani Cave (after: Vahdati-Nasab & Ariamanesh, 2015: 345).

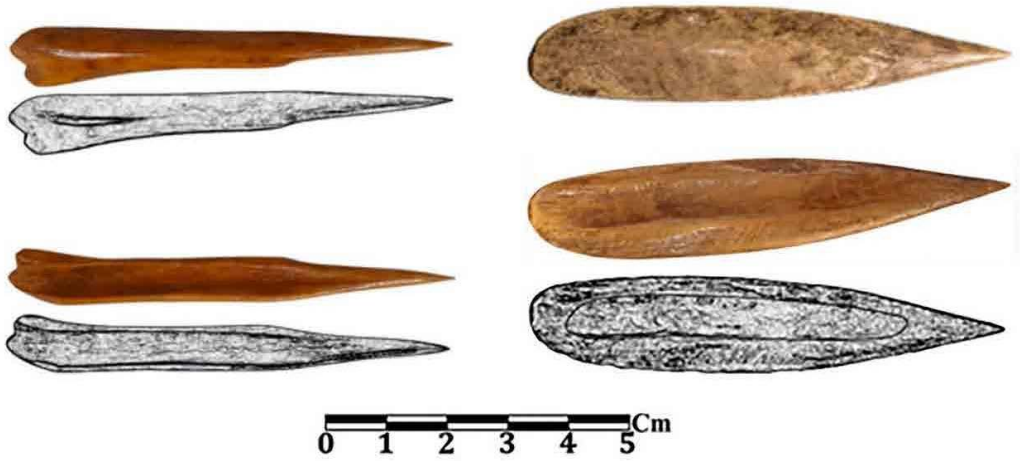

Fig. 10: Bone tools from Hotu Cave (Fazeli-Nashli *et al.*, 2024: 21, Fig. 18).

From southwestern Iran, the bone tools from Chogha Mish deserve mention. At this site, a complete set of bone tools—including awls, needles, polishers, and arrowheads among others—was recovered (Delougaz & Kantor, 1996: Pl. 128), (Fig. 11). The bone arrowhead from Chogha Mish counts among the oldest extant examples of this type in Iran. It should also be noted that animal bone remains were widely used for arrowhead production at Ziwiyeh (Fig. 12), where the most representative and significant examples for study have been found (see: Hassanzadeh & Mashkour, 2023: 47–62).

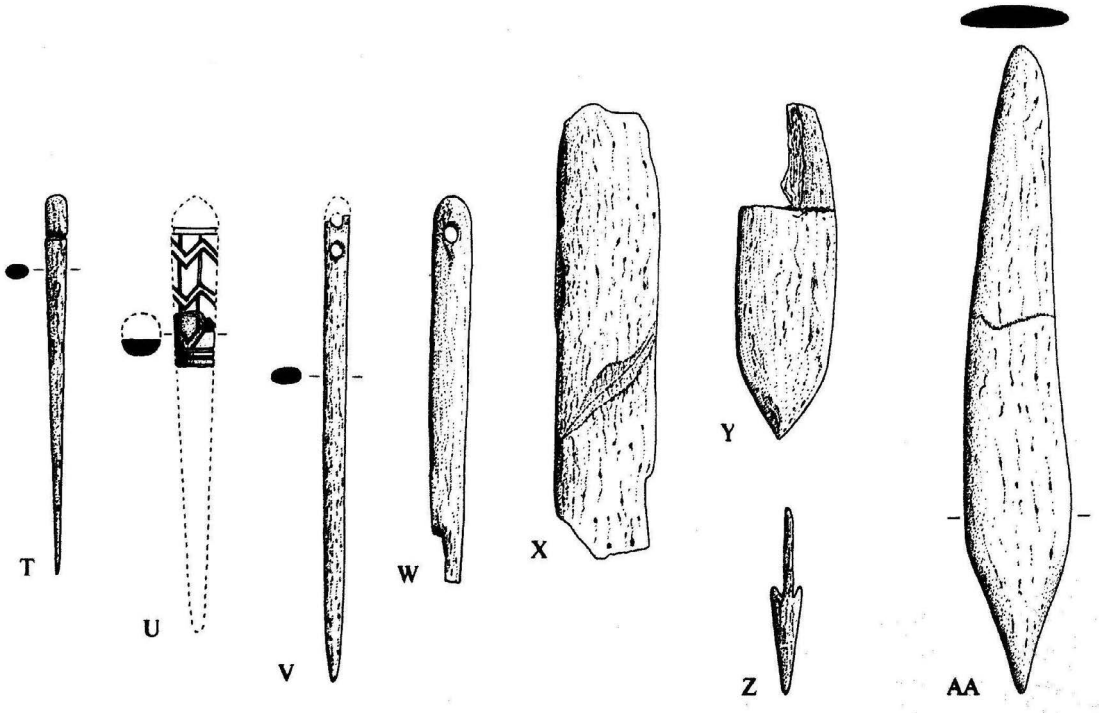

Fig. 11: Examples of bone tools from Chogha Mish (Delougaz & Kantor, 1996: Pl. 128).

Fig. 12: Bone arrowheads from Ziwiyeh (Hassanzadeh & Mashkour, 2023: 51, Fig. 2).

Examples of bone awls have also been found in the Central Zagros highlands, mostly belonging to Neolithic communities, some of which have been reported in scholarly publications (Hamlin, 1975: 125; Voigt, 1983: 29; Braidwood, 1983: 367). Notable and well-reported sites with significant bone tool assemblages include the Neolithic site of Sheikh-e Abad (Matthews et al., 2008), Tepe Abdul-Hosein (Pollard, 1979; cited in Manca *et al.,* 2021), Qalā Gāp (Abdullahi & Sardari Zarchi, 2013; Abdullahi *et al.,* 2014), and Tepe Qeshlaq (Motarjem & Sharifi, 2018; Dehghan & Motarjem, 2024), among others.

From Sheikh-e Abad, 27 bone objects, mostly from ash layers have been reported, comprising fifteen awls, one drill, two polishers, two decorative items, etc. (Fig. 13). The awls were made from the long bones of goat or sheep, with pointed ends, and in some cases, the tips were heat-treated, perhaps for strengthening. Two well-shaped bones from animal ribs, identified as burnishers by the excavators, were also found. Furthermore, two bone objects with perforations were named pendants; one was broken, but the other was complete, featuring two adjacent perforations along with a series of incised lines on its surface. Wear around the perforations suggests probable use as a necklace pendant (Mohammadifar *et al.,* 2011: 29; Matthews *et al.,* 2008: 137–139).

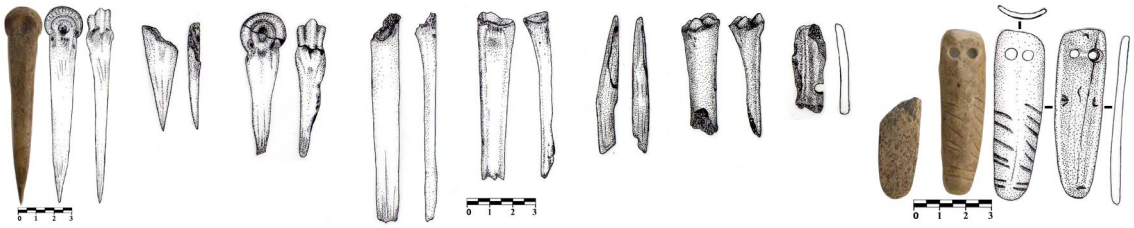

Fig. 13: Bone tools, awls, and a burnisher from Sheikh-e Abad (Matthews *et al.,* 2008: 137, Fig. 11.1 & 139, Fig. 11.4; personal archive of Yaghoub Mohammadifar).

Tepe Abdul-Hosein, another major Central Zagros site and the most important Neolithic site in Nurabad, Lorestan Province, was identified in 1969 during a survey by Clare Goff Mead in collaboration with Roman Ghirshman and Judith Pollard, and excavated by Pollard in 1978 (Pollard, 1979). The site contains evidence from both the Pre-Pottery and Pottery Neolithic phases, as well as their later periods; the aceramic layers are contemporary with pottery Neolithic sites such as Jarmo, Sarab, and Guran. Like other Neolithic sites of western Iran, large numbers of animal remain tools (bone and antler) were found here, making it one of the most important locations for studying the bone tool industries and technologies of the Zagros. The assemblage was studied in detail by Leora Manca and colleagues (Manca *et al.,* 2021). The tools, made from the bones of animals such as goat, include awls and needles (Fig. 14). In total, the animal remains from Tepe Abdul-Hosein comprise 159 bone specimens, six antler items, and three teeth (for more details see: Manca *et al.,* 2021: 28–40).

Fig. 14: Selected bone awls from Tepe Abdul-Hosein (upper row: Manca *et al.,* 2021: 34, Fig. 2; lower row: ©National Museum of Iran archive; photographed by the Authors, 2022).

From the excavations at Tepe Qeshlaq in Kurdistan Province, 40 bone artifacts have been identified as tools, comprising thirteen needles and six awls (Fig. 15). Most tools from Tepe Qeshlaq were made from the long bones of gazelle and wild goat, with a distinct preference for long bones. The longest cylindrical object measures about 11.7 cm. Analysis of the bone texture indicates that craftsmen mainly used natural bone structures without heat treatment, rather than food remains or discarded fragments (Motarjem & Dehghan, 2024: 104).

Fig. 15. Bone cylinder and awls from Layers III and IV, Tepe Qeshlaq (Motarjem & Dehghan, 2024: 105, Fig. 1–2).

From the Neolithic site of Dash Tepe, located in Hamedan Province, fifteen bone tools, including awls, needles, and a polisher, were recovered from sections damaged by illicit digging. These tools were collected and documented during a field visit by the authors. Based on the pottery collected from the site surface, Dash Tepe dates to the Late Neolithic. The bone tool assemblage includes a variety of polishers (one specimen) and awls (eight specimens), as well as needles (five specimens). Of note are the double-pointed needles, which are rare and noteworthy in their type (Fig. 16). It is worth noting that a double-pointed needle also occurs in the bone tool assemblage from Gerd Ashvan (Sharifi & Salimi, 2023: 117, Fig. 20, No. 5).

Fig. 16: Various bone awls and tools from the looted excavation section of Dash Tepe, Razan (Authors, 2018).

4. Theoretical Foundations (Experimental Archaeology)

As is well known, ethnoarchaeology, as an interdisciplinary approach within archaeology, uses the study of living communities and their comparison with past material data to foster a better understanding of the function, production, and meaning of ancient tools. Its theoretical framework incorporates perspectives of processual "New Archaeology" (Johnson, 2002: 5). This method, by employing various ethnoarchaeological analogies, enables the precise reconstruction of operational sequences in the production and use of tools, thereby preventing the misinterpretation of data. The approach is grounded in analogical reasoning: by comparing structures, processes, and behaviors in contemporary communities with past artifacts and material evidence, it seeks to achieve a deeper grasp of the function, production, and use of ancient tools. John Yellen (1977) identified four types of ethnoarchaeological analogy: the general model, the buckshot, the spoiler, and the laboratory. Each of these methods, in different contexts, contributes to the more accurate analysis of tools and helps avoid the erroneous extension of short-term data to long-term interpretations. Ethnoarchaeology, by differentiating functional from stylistic attributes of artifacts

(Sackett, 1990), facilitates the reconstruction of the operational sequence of tool production, use, and discard, leading to a more profound understanding of cultural and technical interactions. From this perspective, tool analysis is not limited to examining form or raw material; rather, such objects are situated within their cultural–social contexts, so that in addition to understanding the technology they also reveal aspects of past identities and social relations (Hasler, 2005, cited in: David & Kramer, 2001: 75). In analyzing tools, if appropriate questions are posed of artifacts, these can yield insights into how humans adapted to their environments, what social arrangements they had, and the conceptual systems they maintained, in other words, how they influenced the world, one another, and themselves. These categories correspond to the three well-known subdomains of "culture" proposed in Lewis Binford's theory (1962; 1965): Technomic – interaction with the material environment; Sociotechnic – interaction with others in social contexts; and Ideotechnic – interaction with ideas, beliefs, and symbolic systems. Yet, in dealing with tools, the challenge remains that archaeologists encounter only the end products of human behavior and must therefore rely on morphological features of artifacts for classification and seriation (temporal/typological ordering). Through these methods and other forms of analysis, they define tool kits and draw inferences about socio-cultural systems (David & Kramer, 2001: 162).

In the broader perspective of Nicholas David and Carol Kramer five steps are proposed for the analysis of ancient tools using an ethnoarchaeological approach. Selection of a sample of tools: Choosing a set of archaeological tools (for example, stone tools, bone implements, or decorative ceramics) from a specific archaeological site. Collection of ethnographic data: Gathering ethnographic information on the production, use, and discard of similar tools in contemporary communities with comparable cultural and environmental settings. Descriptive and comparative analysis: Examining the morphological features, manufacturing techniques, and use-wear of archaeological tools and comparing them with ethnographic data. Reconstruction of the operational sequence: Identifying the stages of production, use, and discard of tools with the aid of ethnoarchaeological models. Cultural interpretation: Analyzing the results within the framework of cultural, social, and technical models to gain a better understanding of past lifeways (see: David & Kramer, 2001: 163). These methods have not been without criticism. They outline a set of arguments and responses through which the duality of views on analogy raised by critics has taken specific shape. This debate focuses on the growing concern that analogy appears both essential for interpretation and yet always potentially misleading. At a more fundamental level, these discussions can be seen as reflecting a core dilemma faced by archaeologists in using their data seriously as evidence of the cultural past: namely, that any broadening of research scope comes only at the cost of reduced (actual or potential) methodological precision. Each critical reaction to analogy, and each corrective response to such criticism, represents an effort to confront this dilemma. Some accept one of the available methodological options, assuming research is inevitably limited or tentative. Others reject these options altogether and seek to demonstrate how one of the assumptions underlying the dilemma might be modified to escape it (for further discussion, see: Wylie, 1985: 63–111).

Within this context, "Analogy" that is, comparison, resemblance, or metaphor has been developed in ethnoarchaeological studies to provide better anthropological parallels and thereby assist in interpreting archaeological data. Put simply, analogy is used when attempting to understand something new or complex by comparing it to something familiar or simple. It involves placing two different things side by side because of their similarity in one or more features. In broader terms, analogy means "comparison for better understanding" (David & Kramer, 2001: 75). Adopting this perspective and employing the method of analogy, Vitezović (2020), in his article "Technological changes and innovations in the osseous industries in the early and late Neolithic in the Balkans", provides an in-depth examination of Neolithic tools and offers valuable insights into the identification and interpretation of technological innovations in prehistory.

In the present research, using ethnographic data related to contemporary communities and employing morphological and technical analysis of archaeological specimens through an analogical approach (comparison for better understanding), an attempt has been made to explain not only past technologies but also the cultural and social dimensions of tools. The results indicate that ethnoarchaeology offers an effective approach to achieving deeper insights into the history of human lifeways and their cultural–technical interactions.

5. From Manufacture to Use: Reconstruction of Bone Tools with Reference to Experimental Archaeology

Experimental archaeology (ethnoarchaeology) possesses the potential for application across all historical periods and encompasses subfields ranging from environmental archaeology to archaeological methods of study and investigation aimed at understanding human activities. Such identifications and analyses reveal to all the manner of tool manufacture and use, as well as the ways of interaction and adaptation to the environment. In the archaeological record, examples of bone tools produced through certain manufacturing methods bear striking resemblance to stone tools, yet with the distinction that bone and stone possess different physical properties. Nevertheless, the structural suitability of both has been considerable for toolmaking, depending on the specific need (Udaya Kumar, 2023: 280). Among these, the bones identified as tools have been examined to provide a better picture of technological adaptation and the cultural traditions of prehistoric humans. In the twentieth century, bone tools came to be regarded as an innovation in early tool production (Backwell *et al.,* 2014: 950). Consequently, zooarchaeology, social archaeology, and the emergence of archaeozoology have offered the potential to examine marrow as food, as well as to analyze and develop the technology of bone industries for toolmaking. The study of animal bones from archaeological sites has aimed to provide insights into human behavior in the past (Gates St-Pierre, 2007: 107).

As mentioned earlier, in archaeological sites of Iran, numerous tools have been identified including drills, knives, scrapers, grinders, projectile points, needles, awls, and so forth and these industries form one of the important components in defining sites. However, their function and use have often been forgotten or mentioned only briefly and in a limited manner. The study of

bone tools still remains dominated by morphological (typological) description, and little effort has been made to understand their technological aspects (Udaya Kumar, 2023: 280).

- Manufacturing techniques: The methods and techniques of bone tool production have shared notable overlap and consistency of application across nearly all human cultures and periods, from the Paleolithic to recent centuries. These include softening, percussion, scraping, splitting, cutting, grooving, heat treatment for hardening, and so forth. Ultimately, these tools fall into two main categories: Hunting tools – such as projectile points and spearheads. Domestic and industrial tools – such as needles, polishers, blades, knives, perforators, and so on (Gupta, 2021: 221–222). In a broader view, the application of methods for working and cutting bones may be classified into four techniques; Grooving, Splitting, Percussion (Taha, 2014: 44–45), Polishing and sharpening. These together comprised the principal approaches to bone tool manufacture (see: Fig. 17).

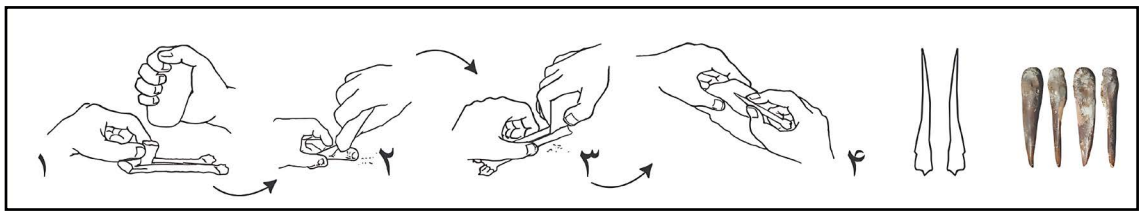

Fig. 17: Reconstruction of the bone tool manufacturing process, from percussion to shaping (Authors, 2024).

Manca and colleagues (Manca *et al.,* 2021), in their analysis of the bone tools from Tepe Abdul-Hossein and Sang-e Chakhmaq, have provided a detailed description of the manner and stages of bone tool production. The principal stage consisted of the general shaping of the tool, carried out through two fundamental methods: 1) bipartitioning, and 2) fracturation. These processes were performed using fresh bone raw materials (prior to fossilization). Following these two stages, the subsequent steps, namely shaping the pieces according to the intended function of the tools were undertaken. These included: 1) scraping, 2) retouching, and 3) abrasion. However, among the assemblages, there are occasionally tools that were used directly as intermediary implements without any specialized shaping or particular finishing. It is noteworthy that the selected bones were predominantly from small mammals and sheep/goat caprines (Manca *et al.,* 2021: 38) a point also mentioned in studies and descriptions of tools from other sites, such as-e Abad (Mohammadifar *et al.,* 2011: 29) and Qeshlaq (Motarjem & Dehghan, 2024: 104), where the raw materials were mainly long, elongated bones, and at times the ribs of hunted domestic and wild animals such as gazelle, goat, and sheep. Based on the study of tools from the Neolithic community of Tepe Abdul-Hossein, compared with those from Tepe Sang-e Chakhmaq, it has been established that Neolithic societies employed organized production systems for bone tools. Tool manufacture was carried out through the conscious selection of bone raw materials, based on the physical properties of the bones and the intended function of the tools (Manca *et al.,* 2021: 39–40).

- Application methods: Regarding the known uses of bone tools particularly awls, it can be stated that during the Mesolithic, the transitional phase to the Neolithic, and the Neolithic to the

Chalcolithic periods, these tools were employed alongside the making of blades and micro-blades in the production of sickles, within the so-called "Mousterian-related and post-Mousterian" tradition from antler and bone tools, for the detachment of blades and micro-blades from cores. This tradition, which began in the Zarzian and Zawi Chemi cultural contexts, focused on the tangential pressure technique for the production of micro-blades and blades from cores, which, in the Neolithic, took on a more specialized character and often appeared in the "bullet-shaped" form. Such specialization, noted at Sheikh-e Abad with the increase in sickle blade counts in later layers, subsequently became widespread in sites such as Chia Sabz-e Sharqi and in most sites dating from the tenth and ninth millennia BCE to the Chalcolithic period, known as the post-Mousterian tradition. This tangential pressure method was simultaneously employed in the Levant in the production of large projectile point industries and bifacial tools (Kozlowski, 1996; 1999). The use of the pressure debitage technique for producing long blades and sickle-related elements is one of the most important characteristics of this tradition, which ultimately, in the sixth and fifth millennia BCE of the Zagros, is defined as the "post-Mousterian" toolmaking tradition (for further information, see: Darabi, 2013: 7–24). Thus, one of the most significant applications of bone tools particularly the awl from the Mesolithic and Neolithic through to the Chalcolithic was in the production of blades and micro-blades via the tangential pressure technique (in Fig. 18, the operational process of this method is illustrated).

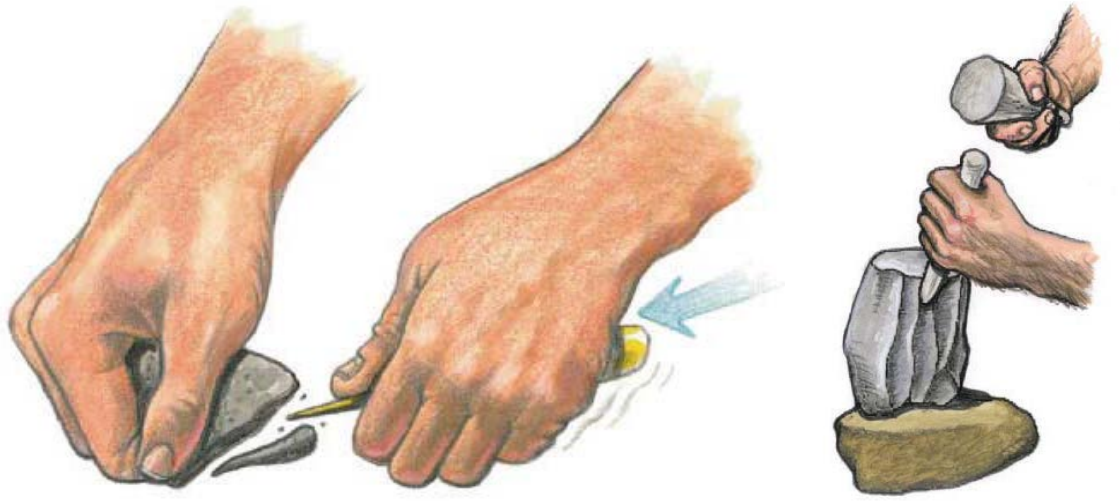

Fig. 18: Use of bone tools (such as the awl) from the Mesolithic, Neolithic, to the Chalcolithic "Mousterian-related and post-Mousterian" periods in the manufacture of stone tools (blades, microblades, etc.), (© Lewis *et al.*, 2012: 299, Fig. 12 19 & 300, Fig. 12 21).

Building upon experimental archaeology, and employing the method of analogy, reference is here made to certain handicraft productions of contemporary traditional communities in which awls and needles constitute essential tools. These tools can be matched with similar examples from earlier periods, prior to the awareness of metal. Through the analysis of the recovered tools within the framework of ethnoarchaeological and comparative ethnographic approaches, cultural patterns and techniques for manufacturing bone tools have been identified. It must first

be recalled that ethnology examines the patterns of thought and behavior of past communities by considering how these might be employed within present-day systems; ethnologists study contemporary cultures and compare them with those of the past. There is no doubt that many ethnologists and ethnographers are capable of examining the relationships between material remains and their structural relationships, in connection with ways of life, such that their principal aim is understanding the past through observation of today's traditional societies (Alizadeh, 2004: 75–77).

Among these, the art of basketry is considered one of the ancient Iranian crafts, having produced many innovations and products, and practiced in regions where the climate has been relatively favorable and accompanied by high-quality vegetation (trees). The Malayer region in Hamadan Province, for instance, has, up to the present day, used this craft (basket weaving or wicker weaving) to represent itself at the national level. In basketry, the core coiled method, generally designed on the basis of mental concepts and patterns is employed. One of the important tools for joining plant elements (reeds) together has been the awl and the needle, which have remained in use to the present day, facilitating the work of artisans (Shah Hosseini & Hajian Foroushani, 2023: 32–33), (Fig. 19: No. 1).

Another use of bone tools (various types of awls and needles) has been in the pottery industry. In this technique, when the clay vessel has not yet dried and its surface is still wet, sharp tools are used to remove clay in order to create incised decoration. Notable examples of this decorative method are seen in the pottery tradition of the Dalma culture, known as pinch decorated pottery, in which a pointed tool (awl) was employed in the process (for examples, cf.: Balmeki, 2017: 69, Fig. 6; Sharifi, 2024: 21, Fig. 8). The same method, in the past, was also employed by potters in the traditional pottery workshops of Lalejin, Hamadan (Fig. 20). Among the reasons cited for the use of bone in traditional pottery making in the past few centuries is its greater resistance to the moisture of pottery clay in comparison to wooden and metal tools. Furthermore, after the pottery had dried, potters would also use sharp tools or blunt edges for decorating the surface with various colors (Fig. 19: No. 2).

Another category of tools worth explaining are the weaving bone tools, tangible and exemplary specimens of which have been identified from the Neolithic period at the sites of Tepe Qalā Gāp (Abdullahi & Sardari Zarchi, 2013: 130), Gerd Ashvan (Sharifi & Salimi, 2023: 115, Fig. 15), and Tepe Posht-e Forudgah. These tools, given their structure and the sharpness present both at the tip and along the sides, bear a strong resemblance to modern traditional crochet hooks (Fig. 19: No. 3). The technique of using these tools, in earlier examples, was also employed in producing early sickles (cf. Figs. 3 & 4). Present day tangible and exemplary parallels include the art of kilim weaving (for more information, see: Faghirizadeh, 2009).

As noted, although tools such as various awls were technologically and intelligently designed and produced for their intended functions, one of the principal and important uses of awls and needles has invariably been as perforators (/borers) in the processes of sewing, weaving, and related tasks. Based on field observations, due to the durability, flexibility, and suitability of metal

tools, in the traditional leather working workshops of Hamadan Province, metal versions of these tools are employed. Among these tools, the following may be mentioned: Gazen (Gāzen): a tool for cutting, scraping, and trimming leather; Awl: for perforating and sewing leather; Hook: for threading and stitching. Given the durability, resistance, and flexibility of leather as well as its importance in early communities this animal derived product (especially among nomadic and transhumant societies) held a crucial place in the production of clothing and various types of leather footwear, among other items. Evidence shows that leather and fiber working have been practiced from remote antiquity up to the present day. Before metals came to be known by humans, bone tools were among the essential implements for leather processing and sewing, and had extensive applications in this field (personal interview with: Mohammad Salim, 2019). Therefore, another major use of bone tools particularly the awl by early communities was in sewing (processing of leather and fibers), (Fig. 22: Nos. 4 & 6).

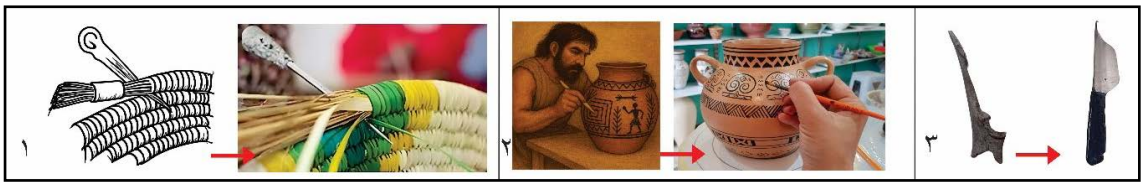

Fig. 19: A brief overview of tools and their applications across different historical periods (basketry image adapted from: Shah Hosseini & Hajian Foroushani, 2023: 32, Fig. 3; with ad ditions by: Authors, 2024).

Fig. 20: A brief overview of "incising" tools and their applications in the pottery art of Lalejin (creating incised decoration using various pointed tools, and separating the shaped vessel from the clay and potter's wheel with a needle and awl), in a comparative analysis with the method of creating pinch incised decoration on Dalma pottery (Dalma pottery images adapted from: Balmeki, 2017: 69, Fig. 6; other images by: Authors, 2025).

6. Bone Tools Discovered at Tepe Posht-e Forudgah

Tepe Posht-e Forudgah, located to the south of Malayer County in Hamadan Province, lies at an elevation of approximately 1,680 m above sea level. The site, with an area exceeding 5,000 m², contains phases of the Late Neolithic, with an absolute date of 5216 B.C.E. (Beik-Mohammadi, 2024: 82), the transitional period from the Neolithic to the Chalcolithic, the Early Chalcolithic, and a short term Islamic occupation during the 3rd–4th centuries AH. The majority of the recovered remains were concentrated in the southern part of the mound. Upon removal

of the surface layers, a volume of ash resulting from the subsistence activities of semi-sedentary and nomadic communities was revealed, together with cultural materials associated with the subsistence economy of such communities (e.g., spindle whorls, clay loom weights, tools made from animal remains, etc.). In the spring of 2017 C.E. (1396 A.H. Solar), the site was examined and subjected to archaeological studies for the purpose of delimiting its boundaries and protected area (for further information, see: Beik-Mohammadi, 2017; Beik-Mohammadi *et al.,* 2018; 2020; 2021). From this site, a total of eight examples of various types of bone tools were recovered, including awls, needles, burnishers, and others, in different dimensions and sizes (Fig. 21).

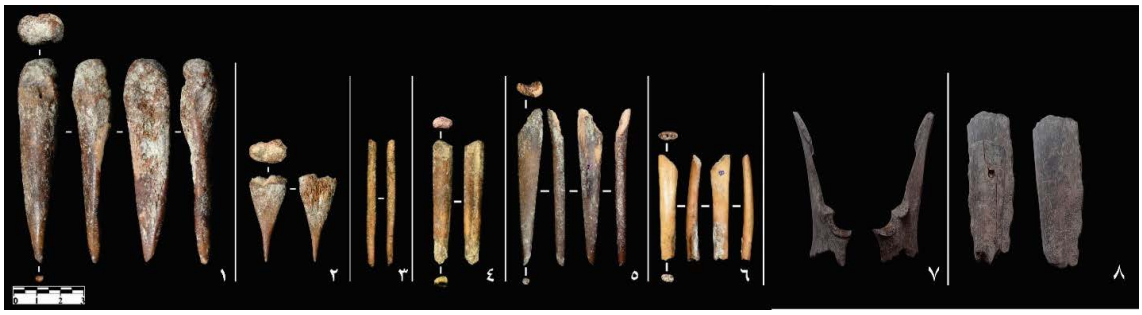

Fig. 21: Examples of bone tools recovered from Tepe Posht-e Forudgah, Malayer (Beik-Mohammadi, 2017).

A technological study and analysis of the bone tool assemblage from the site of Posht-e Forudgah allows for the reconstruction of certain aspects of the production processes and the informed, technical knowledge of its Late Neolithic communities. These tools not only reflect the subsistence needs of the semi-nomadic society of the period but also provide a lucid account of the structure and physical characteristics of the primary raw materials, as well as their functional applications. The morphology and structure of the tools from this site are as follows: elongated, conical, and symmetrical bodies, apparently produced from the long portions of bones; a broad base tapering into a narrow, sharp tip with an oval cross section features that indicate deliberate design for tasks such as perforation (fibers, leather, etc.). The presence of wear and polish marks on the mid section and tip attest to repeated use in production processes (Fig. 21: No. 1). In terms of appearance and structure, this specimen closely resembles tools recovered from other sites, including Yafteh Cave, Abdul-Hossein, Sheikh-e Abad, Qalā Gāp, Qeshlaq, and others (Figs. 5, 6, 7, 13, 14, 15, 16, 17; Table 1: 1).

Another specimen has a triangular body with an oval, nearly solid and compact cross section, preserved in relatively good condition. From a functional perspective, the fineness and sharp tip suggest that it may have been used as a sewing implement or for the production of finer crafts. The high manufacturing quality, sharp tipped and well shaped form of this specimen point to advanced technical skill in producing versatile tools for everyday life (Fig. 21: No. 2); this piece is comparable to specimens from Abdul-Hossein and Sheikh-e Abad (Figs. 13, 14; Table 1: 2).

Another tool is extremely slender and rod shaped, with a solid, circular cross section. Owing to the inherent strength of bone, it exhibits considerable fineness. Such rod like tools, which were recovered in nearly solid form, were likely employed in Neolithic contexts for the production

of handicrafts (basketry, brush making, sewing), (Fig. 21: No. 3); comparable to examples from Sheikh-e Abad, Abdul-Hossein, Chogha Mish, Chogha-Golan, Qeshlaq, and Dash Tappeh (Figs. 13, 14, 15, 16; Table 1: 3).

Other specimens feature an oblique and curved edge, placing their overall form in the category of cutting or abrading implements, functioning as scrapers, blades, and cleaning tools, and are comparable to examples from Sheikh-e Abad, Qeshlaq, and Dash Tappeh (Figs. 13, 15, 16; Table 1: 3). Tools Nos. 4, 5, and 6 exhibit straight bodies of uniform thickness, in some cases with a blunted tip, designed for daily use. Within these finds, the presence of sharper, curved edges, similar to (rudimentary) knives, reveals the existence of relatively sophisticated technologies (Fig. 21: Nos. 4, 5, 6; Table 1: 4, 5, 6); analogous to those observed at Abdul-Hossein (Figs. 13, 15, 16; Table 1: 3). Another tool fragment, with its elongated shape and relatively sharp tip, also belongs to the category of multipurpose implements (blade, scraper, craftwork). The tool's appearance a straight, rod like body with a sharp edge suggests everyday uses such as cleaning tasks or handicraft production (particularly weaving). This resembles examples from Qalā Gāp (Abdullahi & Sardari Zarchi, 2013: 130, Fig. 14) and Gerd Ashvan (Sharifi & Salimi, 2023: 115, Fig. 15), (Fig. 21: No. 7; Table 1: 7).

Another tool, of particular structural and functional significance for understanding and examining the daily life of these communities, is one that has been vertically carved and possesses a flat, elongated surface. What distinguishes this tool from the rest is the presence of a neatly made perforation at the upper part of the bone, likely intended for passing a connector, thread, or perhaps a suspending element, combined with an end that exhibits breakage resembling that of a hammerstone. It is unclear whether the longitudinal cut and fissure along its surface were produced during manufacture or occurred naturally.

A technical examination reveals that the perforation was made with precision; however, due to breakage in the bone, the boring process was not completed, and only the outer surface of the bone was cut. This piece was likely used as a grinding or abrading implement, comparable to examples from Sheikh-e Abad (Fig. 13), Sang-e Chakhmaq (Manca *et al.*, 2021: 34, 11), and Dash Tappeh (Fig. 16), (Fig. 21: No. 8; Table 1: 8).

Although stone tools are present among the bone tools from Tepe Posht-e Forudgah, there is no evidence to suggest that awls were used in stone tool production that is, as tangential pressure tools for producing blades and micro-blades. This is because all of the awls from this site display polished surfaces, contrary to what is observed in studies of tools from Tepe Abdul-Hossein and Sang-e Chakhmaq, where the awls exhibit numerous chipping fractures at the tip and along the body. These fractures have been interpreted as resulting from their use in blade production (Manca et al., 2021: 39 40).

7. Discussion and Analysis

Given the trajectory of animal domestication during the Neolithic and Chalcolithic periods, it can be stated that most animals kept by nomadic-communities were sheep and goats. These animals

Table 1: Examples of bone tools recovered from Tepe Posht-e Forudgah, Malayer, in comparison with other Neolithic sites (Authors, 2024).

No	Image of the tools behind Tepe Posht-e Forudgāh	Attributes of the Tools	Manufacturing Method	Comparable Image	Possible Function	Description		References
						Similarity	Difference	
1		Sharp tip, conical body, polish and wear on the tip	Limited-angle flaking, shaping at the distal end	 Sheykhi-ābād	Drilling	Fully similar in shape and body (spindle-shaped)	There is no difference	Mattews et al., 2008
				 Sheykhi-ābād	Drilling	Similarity in the tip and its sharpness	There is no difference	Authors, 2022; © National Museum Archive
				 Sheykhi-ābād	Drilling	Similarity in the tip and its sharpness	Difference at the distal end, which is also sharper	Abedi, 2015: 7
2		Triangular, sharp-tipped	Retouched at the distal end	 Abdul-Hosein	Drilling, lightweigh t hunting arrowhead	Similarity in tip and sharp distal end	Difference in edge shaping (manufactur ing method	Manca et al., 2021: 43
3		Rod-shaped, thin, and long	Completely polished and dense	 Chogha-Golan	Drilling, similar to a long needle	Similarity in length	Fractured body	Darabi et al., 2024
				 Abdul-Hosein	Drilling, similar to a long needle	Similarity in length	Possessing two perforations along the edge	Authors, 2022; © National Museum Archive
4		Scraper, blade	Lightly flaked, forming an angle on one side	 Abdul-Hosein	Because of the slanted edge: functions include abrasion, cleaning, meat cutting, and scraping	Similar	More prominent edge at Tepe Posht-e Forudgāh	Manca et al., 2021: 43

5		Long, slanted edge	Incomplete flaking at the edge and weakly sharp distal end	 Abdul-Hosein	Because of the oblique edge: functions include cleaning and meat cutting	Similarity in edge and length	The distal end is more chamfered in the specimen	Manca et al., 2021: 43
				 Abdul-Hosein	Because of the oblique edge: functions include cleaning and meat cutting	Similar edge and length in the body	The distal end is more chamfered in the specimen	Manca et al., 2021: 43
6		Long, weak and slanted edge	Flaking or breakage at both the edge and the distal end	 Abdul-Hosein	Because of the oblique edge: functions include cleaning and cutting meat	Central part of the bone, slanted edge	Less sharp compared to the tools from Tepe Posht-e Forudgāh	Manca et al., 2021: 43
7		Narrow and elongated, sharp	Flaking or breakage at both the edge and the distal end	 Qalā Gāp	Sharp and cutting, blade, scraper, handicraft	Sharp and narrow edge	Tools from Tepe Posht-e Forudgāh are sharper and thinner, providing ease of use	Abdollahi & Sardari Zarchi, 2013: 130, Figure 14
				 Gerd Ashvan	Sharp and cutting, blade, scraper, handicraft	Sharp and narrow edge, Tip fracture of the tool	Tools from Tepe Posht-e Forudgāh are sharper and thinner, providing ease of use	Sharifi & Salimi, 2023: 115, Fig. 15
8		Flat with rounded edge	Flaking or breakage on both the edge and the distal end	 Sheykhi-ābād	Used for cleaning, scraping, and abrasion	Similar	They do not differ	Mattews et al., 2008
				 Sang-e Chakhmaq	Used for cleaning, scraping, and abrasion	Similar	They do not differ	Manca et al., 2021: 34, 11
				 Dash Tepe	Used for cleaning, scraping, and abrasion	Similar	They do not differ	Authors, 2018;

were among the most beneficial and best adapted to the environment (especially in the Zagros), (Zagarell, 2008: 104). Zooarchaeological studies indicate that the bones of these two species (including sheep and goat) were extensively utilized in tool manufacture. A general overview of the tools recovered from Tepe Posht-e Forudgah, Malayer, shows considerable diversity in form, manufacturing techniques, and probable functions. Zooarchaeological research across various periods, particularly in prehistory, has been of central importance, and alongside it, the study, analysis, and functional interpretation of bone tools offers essential insight. Through the identification and examination of different species, whether domesticated or wild, it also becomes possible to better understand the animal and plant ecosystems; within this process, the products of earlier human communities play an important role in understanding their culture and society. Before the introduction of metals, one of the most important cultural materials was hard substances such as stone and bone. Stone tools and processing techniques have greatly contributed to our understanding of past economies and consumption patterns, and bone data are no exception they, too, shed light on and facilitated aspects of human life. In general, the applications of tools (including those from Posht-e Forudgah) can be divided into two groups: Tools with more specialized and precise functions. Tools with more general, processing level applications.

These, in turn, fall into two main categories: first, pointed tools with conical or spindle shaped bodies, generally designed for perforation and sewing; and second, tools with worked or oblique (weaker) edges, used for incising or engraving. From a technological perspective, the available evidence indicates that these tools exhibit polished and worn surfaces, created by repeated use over their working lives. The perforating and scraping tools from Tepe Posht-e Forudgah display notable fineness. Their dimensions and proportions are such that they enhance the user's control due to their well considered sizing, thereby facilitating work. From an ethnographic perspective, it can be deduced that these tools were used in the production of handicrafts such as basketry, pottery, and domestic crafts. As noted earlier, experimental archaeology seeks to explore past art, culture, and technologies in order to present them within today's traditional societies. Accordingly, it can be said that raw materials in the past, as natural and readily available resources for manufacturing a range of tools, have persisted though with changes in material in similar forms and functions in contemporary traditional communities. It should be noted that bone, thanks to its physical properties and high durability, was capable of fulfilling human needs. For example, an awl, used by many artisans in basketry to divide and arrange the work, was made with a relatively long body and a sharp point to facilitate the craft. In modern basketry, this implement is used almost in the same form (Shah Hosseini & Hajian Foroushani, 2023: 32–33), the only difference being the material composition (Fig. 22: No. 1). Another tool, found in Neolithic contexts including Chogha-Golan and Tepe Posht-e Forudgah, is a long rod. Unfortunately, in both sites, the specimens appear to have been broken, preventing precise measurement of their dimensions. However, given their thinness and delicacy, it is plausible that these may have served as knitting needles comparable to those used today in traditional kilim weaving in various parts of Iran (Fig. 22: No. 2). Another example of a domestic craft tool is one comparable to a weaving knife. Similar implements have

been recorded at Qalā Gāp, classified as weaving tools (Abdullahi & Sardari Zarchi, 2013: 130, Fig. 14), and at Gerd Ashvan (Sharifi & Salimi, 2023: 115, Fig. 15). The specimen in question, made from the central portion of a bone, was thin and sharp and likely used for cutting thread; it is also possible that the tip had an additional function, serving as a hook (Fig. 22: No. 3). Among other branches of animal product processing is the craft of tanning. This traditional technique maintaining its essential nature, and even its raw materials persists to this day. Animal skins, treated with chemical agents (in the past, salt) and physical manipulation, were transformed from their raw state into relatively stiff and decay resistant sheets (Saadian, 1970: 157). Another tool, retaining its functional concept, is the "Knife/Cleaner tool" used for cleaning meat, plant skins, and similar materials. Present in modern domestic contexts as well, this implement is represented at Tepe Posht-e Forudgah by a specimen with a sharp and cutting tip and body, likely used for scraping and cleaning (Fig. 22: No. 5). Sewing, like knitting, has a variety of tools, which in the past were made of bone and today are typically of metal. The primary form was the awl or punch, used for perforation and for passing connectors (Fig. 22: No. 6), as well as needles that could be employed for both sewing and weaving (Fig. 23).

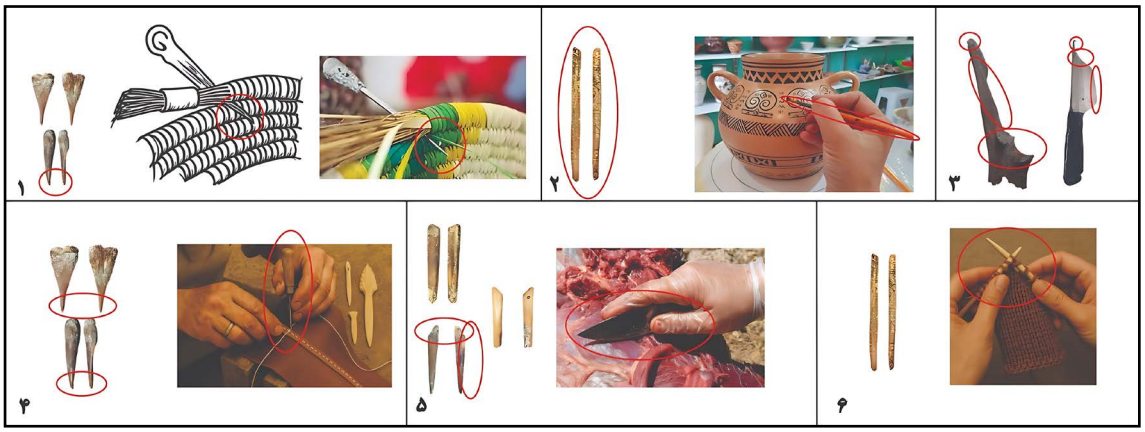

Fig. 22: Comparison of past and present tools used in basketry (basketry image adapted from: Shah Hosseini & Hajian Foroushani, 2023: 32, Fig. 3; Authors, 2024).

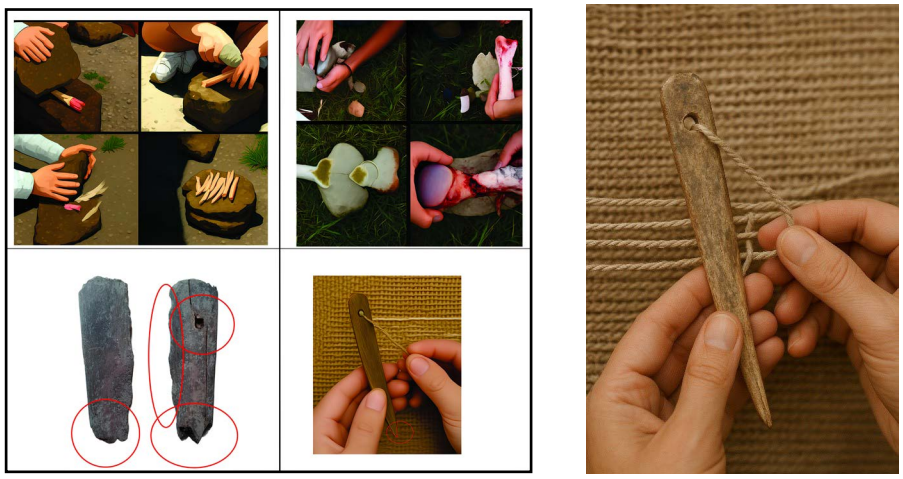

Fig. 23: Process of bone tool production through to stages of use (Authors, 2024).

8. Conclusion

The study of bone artifacts has not received serious attention in Iranian archaeology, except in a few cases to which reference has been made in the body of this research. This neglect stems from an insufficient understanding of their practical functions and applications. However, with a thorough knowledge of such objects, they can serve as connectors between cultural sequences. By examining the subsistence strategies and cultural exchanges of past communities, the dynamic and intelligent adaptations of human societies can be discerned. Accordingly, the study of bone artifacts in this research shows that although their quantity at the site of Tepe Posht-e Forudgah is limited, they nonetheless contribute to confirming the subsistence economy of this region's nomadic and semi sedentary community, based on pastoralism. Although few in number, the bone tools and associated data indicate the intelligent use of resources and a high level of technical skill, embedded within a self sustaining internal economy. These implements were used for domestic tasks, and preliminary examination suggests that they bear traces of wear as a result of prolonged use during their time. It should be noted that most of the materials examined here show a high degree of overlap with finds from other Neolithic sites, which indicates the diffusion of shared traditions in the manufacture, finishing, and use of bone artifacts within a common cultural horizon. However, it must be borne in mind that Tepe Posht-e Forudgah was a seasonal and nomadic settlement center. Compared with larger sites which accommodated greater human populations, it held fewer inhabitants and thus yielded fewer artifacts overall. Nevertheless, it produced tools in accordance with the needs of its community. Ultimately, it may be concluded that, given the semi sedentary and nomadic lifeways of the region, the recovered bone tools were purposefully made to meet the subsistence needs of the society. This is observable in the specialized morphology of the tools, reflecting their role in crafts and daily life. When bone artifacts are considered alongside other abundant site finds especially "Spindle Whorls" it becomes clear that they were employed in sewing, weaving, and possibly spinning, as well as basketry, mat weaving, and even leather working. Based on parallels from contemporaneous sites, these implements show extensive similarity in morphology, structure, and function. Moreover, when compared with present day experimental archaeological studies in the region, modern examples of bone tool use especially awls and needles clearly point to their role in activities such as decorating pottery, sewing, weaving, leather working, and related tasks.

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Authors' Contribution

All authors contributed equally to the writing of this paper.

Conflict of Interest

The authors hereby declare, in adherence to publication ethics and proper citation practices, that there is no conflict of interest.

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ساخت و کاربری ابزارهای استخوانی در جوامع نوسنگی: مطالعه‌ای بر ابزارهای استخوانی محوطهٔ تپهٔ پشت‌فرودگاه ملایر

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چکیده

محوطهٔ تپهٔ پشت‌فرودگاه در دشت ملایر، در زمرهٔ محوطه‌های شاخص جوامع نیمه‌کوچ‌رو با اقتصاد معیشتی دامداری، از اواخر نوسنگی جدید در زاگرس‌مرکزی به‌شمار می‌رود. در این دوران با تثبیت شیوه‌های کشاورزی و دامداری، منجر به گسترش و تنوع در ساخت ابزارهایی از مواد خام سنگ و به‌ویژه بقایای جانوران (استخوان) شده است. بقای استخوان‌های جانوری به‌دلیل دارا بودن ویژگی‌هایی همچون: انعطاف‌پذیری، قابلیت پرداخت، مقاومت نسبی و دسترسی آسان، نقش مهمی در زندگی و معیشت جوامع نوسنگی داشته است. در این پژوهش، تعداد محدودی از ابزارهای استخوانی که با ابعاد و ویژگی‌های ظاهری و عملکردی مختلف به‌دست آمده از محوطهٔ تپهٔ پشت‌فرودگاه به روش توصیفی-تحلیلی و مقایسه‌ای با سایر محوطه‌های شاخص زاگرس‌مرکزی مورد بررسی قرار خواهند گرفت. پرسش نخست در این باب آن است که، ابزارهای استخوانی به‌دست آمده از محوطهٔ پشت‌فرودگاه ملایر دارای چه ویژگی‌ها و خصوصیات ریخت‌شناسی و عملکردی هستند؟ دوم، با توجه به ساختار ابزارها، چه نقشی در زندگی روزمرهٔ جوامع کوچ‌رو و به چه‌منظور مورداستفاده بوده‌اند؟ و پرسش‌آخر، بین ابزارهای این محوطه و سایر محوطه‌های هم‌عصر و هم‌افق خود، قرابت ساختاری و کارکردی وجود دارد؟ این پژوهش به‌دنبال اهدافی چون: تحلیل ویژگی‌های ریخت‌شناسی، فناوری هوشمندانهٔ مردمان و کارکرد احتمالی آن‌ها و با کمک گرفتن از مطالعات باستان‌شناسی تجربی بوده است. یافته‌ها نشان می‌دهد که ابزارها عمدتاً دارای بدنهٔ مخروطی، نوک‌تیز و سطح صیقل یافته‌اند و آثار سایش که نشانگر استفادهٔ مکرر بوده، قابل مشاهده است. نتایج این پژوهش بر اثبات نوعی تخصص‌گرایی در ساخت ابزارهاست؛ آگاهی درست از خواص موادخام استخوانی و شکل‌گیری نظام فناورانه همراه با ساختار اجتماعی پویا در دوران نوسنگی، به‌ویژه در جامعهٔ نیمه‌کوچ‌رو دامدار تپهٔ پشت‌فرودگاه دلالت دارد؛ چراکه با تحلیل ابزارها و بازسازی جنبه‌های معیشتی می‌توان تاحدی ساختار اجتماعی جوامع پیش‌ازتاریخ را بررسی و درک بهتری در نحوهٔ ساخت، استفاده و کاربرد از نوع ابزارهای استخوانی، به‌ویژه درفش و سوزن‌ها در جوامع نوسنگی کوچ‌رو ارائه کرد.

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