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ORIGINAL PAPER

Were tanged points mechanically delivered armatures? Functional and morphometric analyses of tanged points from an Upper Paleolithic site at Jingeuneul, Korea

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Abstract

A total of 99 tanged points have been unearthed from the Jingeuneul site in Jinan-gun, Korea. The exceptionally large number of tanged points suggests a specific site function at this location. Even though the tanged point is one of the representative tool types for Korean Upper Paleolithic assemblages, the function of this tool is not well known because no systematic use-wear analyses have yet been undertaken. Here, we conduct a use-wear analysis of 95 tanged points from the Jingeuneul site. The use-wear analysis reveals that a considerable number of the tanged points show diagnostic impact fractures (DIFs). Because a large number of the tanged points appear to have been used as hunting weapons, a morphometric analysis is also undertaken to examine the potential projectile capability of the tanged points with DIFs. The large dimension of the DIFs and the complex fracture pattern of the tanged points, as well as the small morphometric values of the tip cross-sectional area, tip cross-sectional perimeter, and neck width of the tanged points, all suggest that the tanged points from the Jingeuneul site were mechanically propelled using a spear-thrower or a bow.

Keywords Tanged points · Use-wear analysis · Mechanically delivered armatures · Upper Paleolithic · Korea

Introduction

The first Korean Upper Paleolithic excavation at Seokjang-ri in 1964 revealed blade tools with a tanged base (Sohn 1967) that were previously unknown in the Korean Peninsula. In the 1980s, morphologically identical stone tools were unearthed at Suyanggae, which were then labeled tanged points (Lee 1985). Subsequently, tanged points were found all over South Korea and are now one of the representative tool types for Korean Upper Paleolithic assemblages (Matsufuji 2004; Seong 2008, 2015; Lee 2012, 2015a).

The transition from the Middle to Upper Paleolithic in Korea is represented by the introduction of blade production, the use of finer raw materials, and new tool types, such as tanged points (Lee 2006). Therefore, tanged points appear at the beginning of the Korean Upper Paleolithic, dated to approximately 40 ka (Han 2003; Seong 2008, 2011; Lee 2015a). Thereafter, lithic assemblages are dominated by tanged points and other blade tools, including end scrapers, sidescrapers, burins, and denticulates. After microblades appeared in the Korean Peninsula at ca. 25 ka, both tanged points and microblades represent the late Upper Paleolithic assemblages until around 13 ka (Lee 2015a, b). Tanged points are primarily made on blades exhibiting either a naturally pointed tip or a pointed tip made by retouching (Chang 2002; Lee 2011).

Due to their symmetric pointed form, tanged points have been assumed to have been used as spear tips (Lee 1985; Chang 2002). Seong (2008) suggested that the breakage pattern of tanged points at the Yongsan-dong site, characterized by a frequent lack of tips and broken bases, indicates that tanged points were mounted on a spear. However, Upper Paleolithic hunting weapons in the Korean Peninsula are not well known because no systematic use-wear analyses have yet been undertaken for tanged points and other tool types as well.

The Jingeuneul site is an Upper Paleolithic site in the south-western region of Korea and has yielded 99 tanged points,

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which is an exceptionally large number (Lee 2004). Due to its large number of tanged points, the Jingeuneul site is the best sample available to examine the function of the tanged points. Therefore, a use-wear analysis of tanged points from the Jingeuneul site was undertaken to reveal their function. A previous morphological analysis of the Jingeuneul tanged points indicated the small dimension of the bases of the tanged points (Lee 2011). This small dimension suggests that the shafts for the Jingeuneul tanged points were also thin and this could be related to the projectile system. Here, we undertook a morphometric analysis to determine the potential capabilities of the tanged points as projectiles.

The Jingeuneul site

The Jingeuneul site is an Upper Paleolithic open-air site located on a gentle slope beside the upper stream of the Geum River in Jinan-gun, Korea (Fig. 1a, b). The excavation of the Jingeuneul site revealed two cultural horizons: an Upper Paleolithic horizon and a Middle Paleolithic horizon (Lee 2012) (Fig. 1c). The stratigraphy at the Jingeuneul site comprises bedrock, fluvial gravel deposits (~ 4 m thick), and Pleistocene and Holocene sediments (~ 5.5 m thick), from bottom to top, respectively. The Pleistocene sediment is further divided into five layers based on the sediment color, components, and particle size: layer 6, lower red-brownish sandy clay; layer 5, dark-brownish sandy clay with angular gravels; layer 4, upper red-brownish sandy clay; layer 3, dark-brownish sandy clay; and layer 2, with light-brownish clay. The Middle Paleolithic horizon is at the top of layer 5, while the Upper Paleolithic horizon is on the lowermost level of layer 2. The Holocene sediment covers the surface. Even though the Middle Paleolithic layer includes only four pebble tools, the Upper Paleolithic layer provides a rich lithic assemblage, comprised of approximately 12,000 lithic artifacts. The unearthed lithic artifacts show at least 26 spatial concentrations (Fig. 2), and two hearths have been found close to the concentrations. Two radiocarbon determinations measured on charcoal from hearth numbers 1 and 2 were dated at 22,850 ± 350 BP (SNU 01-028) and 17,310 ± 80 BP (SNU 04-113) (Lee 2004), respectively, and were calibrated using the IntCal13

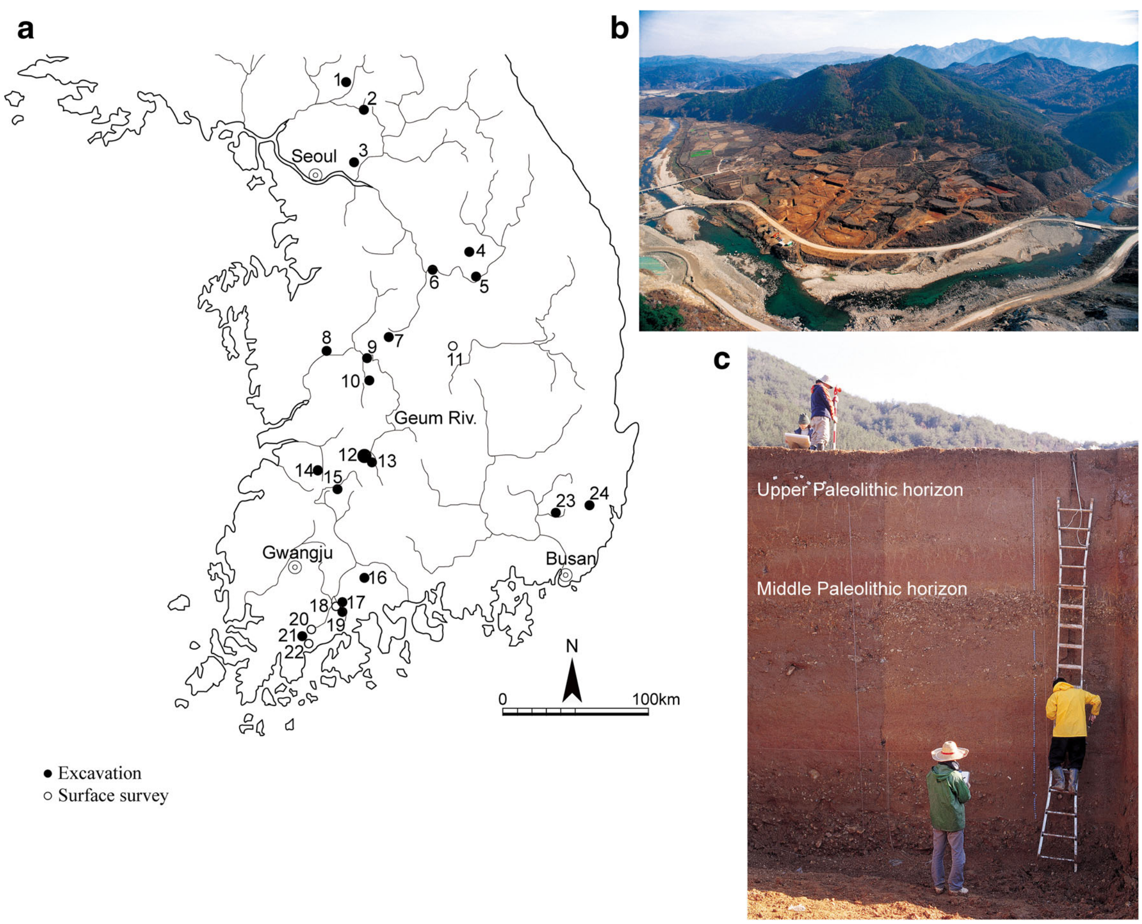

Fig. 1 **a** Distribution map showing Upper Paleolithic sites exhibiting tanged points on the Korean Peninsula, **b** an overhead view of the Jingeuneul site, and **c** a stratigraphic profile. (1) Neulgeori, (2) Hwadae-ri, (3) Hopyeong-dong, (4) Jungmal, (5) Suyanggae, (6) Waesil, (7). Nosan-ri, (8) Seokjang-ri, (9) Yongho-dong, (10) Yongsan-dong, (11) Bangok-ri, (12) Jingeuneul, (13) Chimgok-ri, (14) Bonggok, (15) Haga, (16) Jucknae-ri, (17) Jucksan, (18) Indeok, (19) Wolpyeong, (20) Yongso, (21) Sinbuk, (22) Haeryong, (23) Gorye-ri, (24) Sinhwa-ri

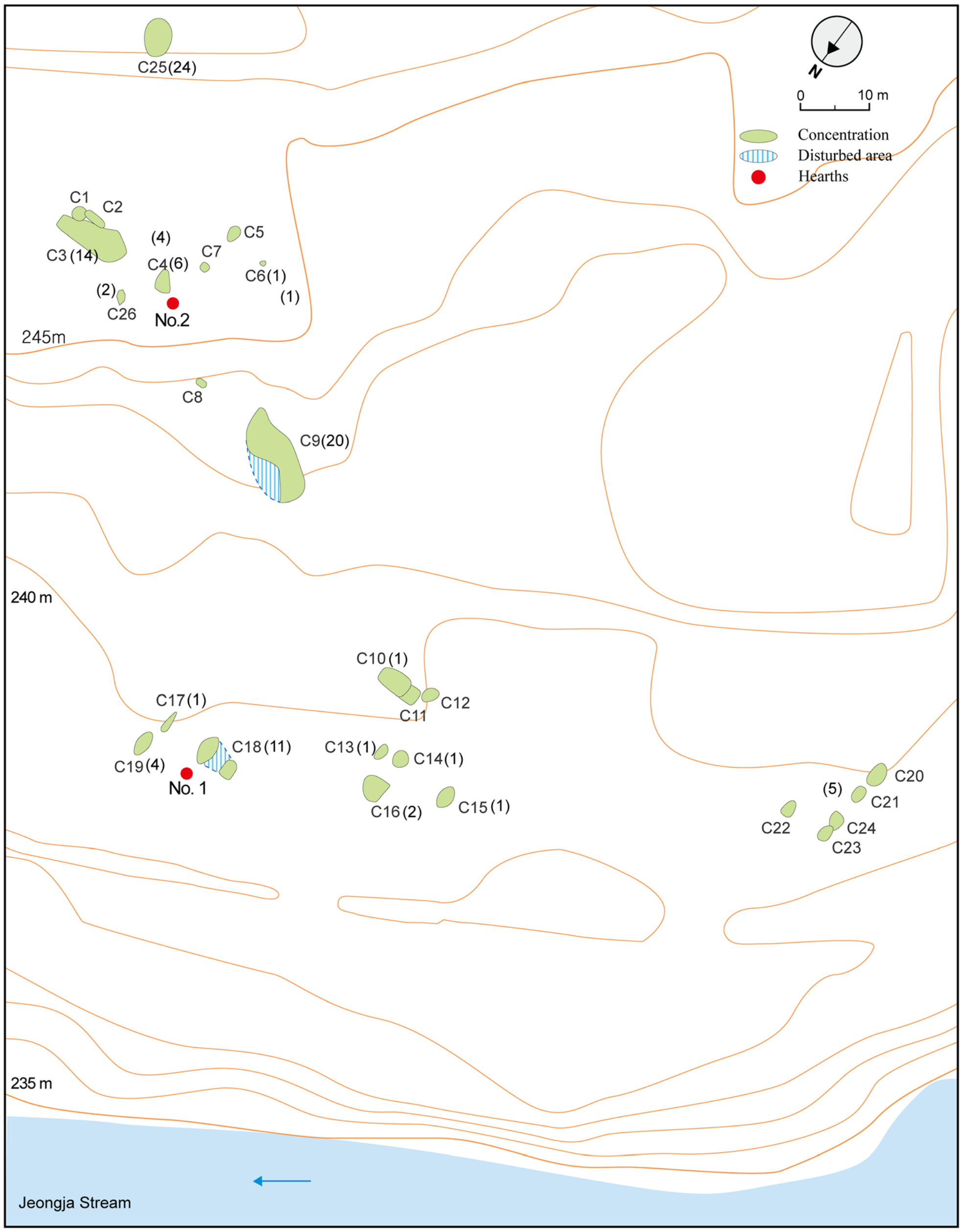

Fig. 2 Distribution map showing lithic concentrations and hearths at the Jingeuneul site. Numbers in parentheses next to concentrations show how many tanged points were recovered from the concentrations, respectively. Isolated numbers indicate counts and approximate locations of tanged points found outside of concentrations

atmospheric curve (Reimer et al. 2013) and the OxCal platform (Ramsey 2009) to c. 27,700–26,400 cal BP (95.4% probability) and to c. 21,100–20,600 cal BP (95.4% probability), respectively. The spatial overlap of the concentrations and the temporal differences between the two hearths, which were spatially distant, suggest that the Jingeuneul site was occupied several times.

The lithic assemblage is primarily composed of blades and by-products of blade production. Most of the lithic artifacts were made on rhyolite. The recovered stone tools are primarily comprised of tanged points but include some end scrapers, sidescrapers, burins, notches, denticulates, awls, and becs. The large number of tanged points ($N = 99$) is distinctive from other tanged point assemblages on the Korean Peninsula and could represent the site function at Jingeuneul (Fig. 3).

Materials and methods

To reveal the functions of the tanged points, a use-wear analysis was performed. A total of 95 tanged points from the Jingeuneul site were macroscopically and microscopically analyzed. The number of the analyzed samples from each concentration is shown in Table 1. The tanged points recovered from the Jingeuneul site were defined by a concave or an oblique base, such as a double concave, concave, and oblique,

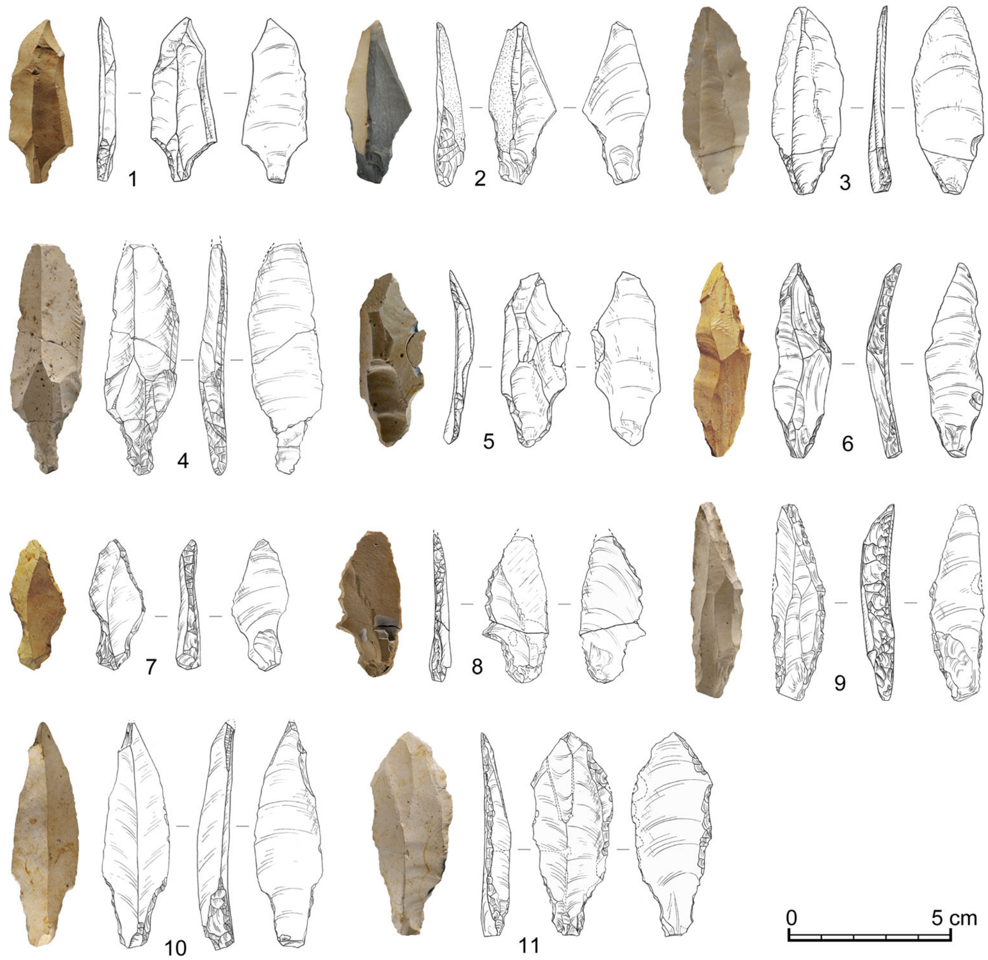

Fig. 3 Representative types of tanged points from the Jingeuneul site

and double-oblique base (Figs. 4[a]–[c]). While blades with a naturally pointed tip were often used as a blank for tanged points (Fig. 4[1]), a considerable number of tanged points also yielded a tip retouched from one or both sides (Figs. 4[2]–[5]). A detailed morphological analysis has already been published (Lee 2011).

Table 1 Number of the analyzed tanged points by concentration

Concentration	Number of tanged points
Concentration 3	13
Concentration 4	6
Concentration 6	1
Concentration 9	18
Concentration 10	1
Concentration 13	1
Concentration 14	1
Concentration 15	1
Concentration 16	2
Concentration 17	1
Concentration 18	11
Concentration 19	4
Concentration 25	24
Outside of the concentrations	11
Total	95

Macro-traces were photographed using a digital single-lens reflex camera (Canon EOS 7D) with a Canon EF 100 mm f/2.8 L IS USM macro lens. Microwear traces were observed using a metallographic microscope (Olympus BXFM) at magnifications ranging from × 100 to × 500 and were recorded using an Olympus DP21 digital camera. Use-wear traces were examined based on previous experimental studies on macro- and micro-traces (Semenov 1964; Tringham et al. 1974; Keeley 1980; Odell and Odell-Vereecken 1980; Kajiwara and Akoshima 1981; Vaughan 1985; Akoshima 1987; Van Gijn 1990; Pawlik 1995; Sano 2012).

Because numerous impact fractures were observed, the fracture patterns were analyzed based on projectile experiments (Barton and Bergman 1982; Moss and Newcomer 1982; Bergman and Newcomer 1983; Fischer et al. 1984; Odell and Cowan 1986; Geneste and Plisson 1993; Sano and Oba 2015; Sano et al. 2016). It is experimentally known that pseudo-impact fractures can occur throughout production

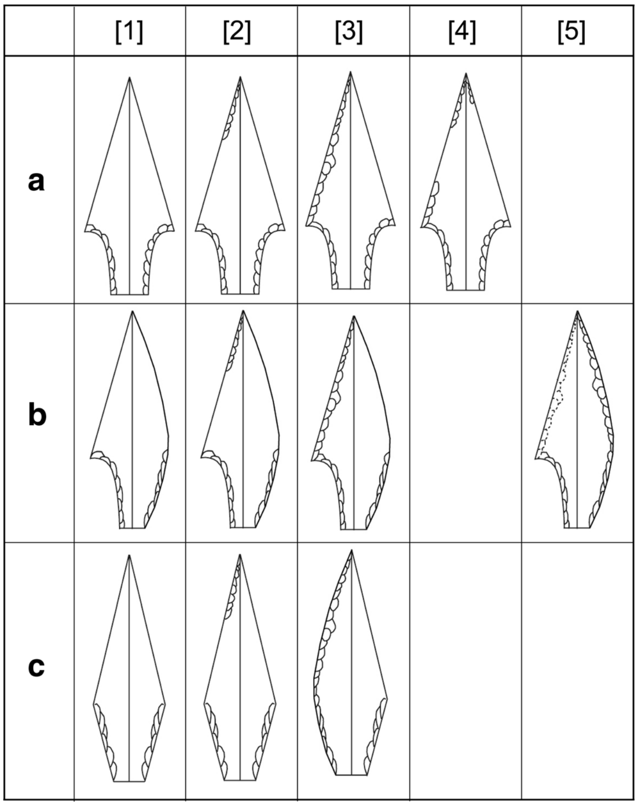

Fig. 4 Subtypes of tanged points from the Jingeuneul site according to base morphology ([**a**] double concave, [**b**] concave and oblique, and [**c**] double oblique bases) and tip retouch ([1] intact, [2] one side partially retouched, [3] one side completely retouched, [4] both sides partially retouched, and [5] both sides completely retouched) (Lee 2011, Fig. 10)

and post-depositional processes (Sano 2009; Pargeter 2011; Pargeter and Bradfield 2012). Based on a comparative study of the fracture patterns of backed points in production and post-depositional experiments (Sano 2009), we considered crushing, flute-like fractures, burin-like fractures, transverse fractures with step, hinge, and feather terminations that obviously formed after lateral retouch, bifacial spin-offs, and unifacial spin-offs larger than 6 mm to be reliable diagnostic impact fractures (DIFs). We use the morphologically labeled term “transverse fracture” as a broadly equivalent term to “bending fracture” because all the impact fractures excluding the spin-offs show a bending initiation (Ho Ho Classification and Nomenclature Committee 1979) and therefore “bending fracture” is a confusing term (Sano and Oba 2015).

The tip cross-sectional area (TCSA) and the tip cross-sectional perimeter (TCSP) are considered to be useful proxies to distinguish dart tips from arrowheads (Hughes 1998) and have been applied to identify delivery modes of archeological hunting weaponry (Shea 2006; Shea and Sisk 2010; Sisk and Shea 2011). Because the TCSA and TCSP values of stone tips may indicate the potential projectile capability (Hughes 1998) independent of geographical regions and chronological periods, the TCSA and TCSP values of tanged points from the Jingeuneul site were compared to those of North American dart tips and arrowheads (Thomas 1978; Shott 1997). The TCSA and TCSP values were calculated using the equation presented by Shea (2006) and Sisk and Shea (2009).

As these values are calculated using the maximum width and thickness (Shea 2006; Sisk and Shea 2009), the tanged points that retained the widest and thickest parts of the specimens were selected for the TCSA and TCSP analyses. However, this is worthless if the TCSA and TCSA analyses are conducted for tanged points that were used as knives or scrapers. Therefore, the morphometric analysis was performed only for tanged points that were thought to have been used as hunting weapons based on the use-wear analysis.

Owing to the morphological features of tanged points, the difference between the maximum width and the neck width is significant. Therefore, the TCSA and TCSP values for the tanged points may not necessarily represent the delivery modes. However, the neck width would have been determined according to the shaft used for the darts or arrowheads and may therefore represent the employed delivery modes. Therefore, the neck width of the Jingeuneul tanged points was also compared to that of the North American dart tips and arrowheads (Thomas 1978; Shott 1997).

Results

Use-Wear analysis

The majority of the 95 tanged points from the Jingeuneul site have developed a white patina that prevents the observation of microwear traces, such as polishing and striations. A macroscopic analysis, the Low-Power Approach, revealed that no clear-edge damage related to cutting or scraping activities had formed on the tanged points. Conversely, more than half of the analyzed tanged points ($N = 66$, 69.5%) showed some type of fracture (Table 2). Only 29 pieces (30.5%) were retained complete or exhibited only modern fractures due to weathering. However, most of the tanged points with fractures ($N = 46$,

Table 2 Frequencies of fractures and DIFs observed on the tanged points

Sample	Tanged points without fractures[a]	Tanged points with fractures	Tanged points with DIFs	Total number of fractures	Total number of DIFs
95	29 (30.5%)	66 (69.5%)	20 (21.1%)	122 (1.28 per piece)	53 (0.56 per piece)

[a] includes specimens with modern fractures due to weathering

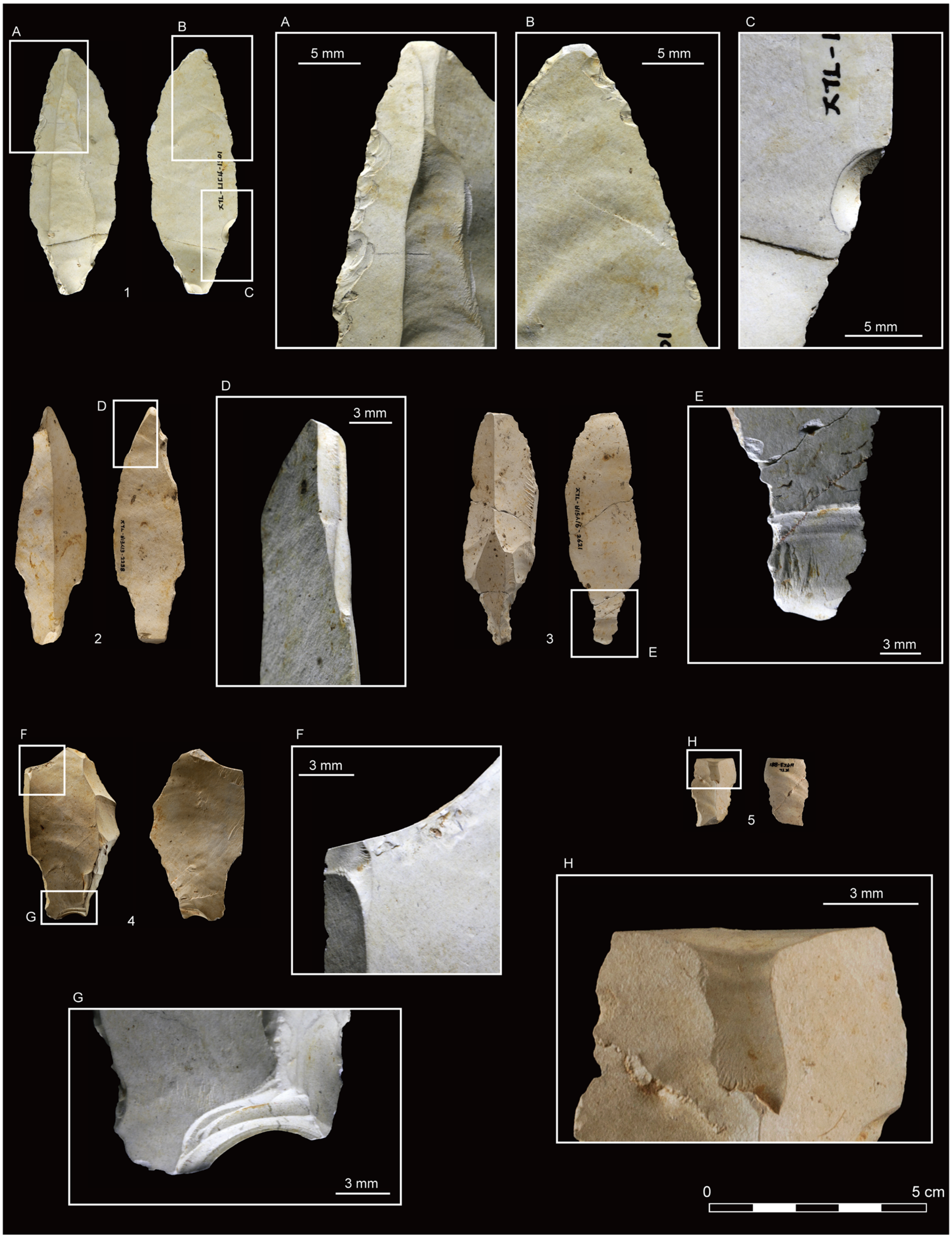

Fig. 5 Tanged points from the Jingeuneul site showing DIFs: **a**, **b** crushing on both lateral edges, **c** crescent scar likely due to hafting, **d** burin-like fractures, **e** flute-like fracture, **f** snap fracture and spin-offs, **g** transverse fracture with step termination, and **h** transverse fracture with hinge termination

48.4%), including the snap fractures, did not indicate diagnostic features for functional interpretation (Fischer et al. 1984; Sano 2009). Therefore, it is impossible to determine the functions of these pieces. Yet, out of the tanged points that were analyzed, 20 pieces (21.1%) showed DIFs that demonstrate their use as hunting weapons.

A large amount of crushing was observed on the lateral edges of the tanged points (Fig. 5a, b; Table 3). Large or

Table 3 Frequencies of the fracture types

Fracture type	*N*	DIF/ NDF
Indeterminate fractures	10	NDF
Snap fractures	41	NDF
Unifacial spin-offs < 6 mm	14	NDF
Transverse fracture with step, hinge, or feather*1	4	NDF
Transverse fracture with step, hinge, or feather*2	18	DIF
Crushing	14	DIF
Flute-like fractures	6	DIF
Burin-like fractures	5	DIF
Bifacial spin-offs	8	DIF
Unifacial spin offs >6 mm	2	DIF

*1 Temporal relationship between fracture and intentional retouch is uncertain or no intentional retouch

*2 Fractures formed after intentional retouch

triangular points more frequently exhibit lateral edge crushing than slim points (Rots and Plisson 2014). The triangular outline of the tanged points likely led to frequent contact between the lateral edges and animal bones. Burin-like fractures were also observed on five pieces (Fig. 5d). However, the number of burin-like fractures is much smaller than that of crushing and transverse fractures and is nearly the same as that of flute-like fractures.

Correlations between DIF occurrences and morphological subtypes are shown in Table 4. As the majority of DIFs occurred on the tip, most of the tanged points lack their tip and do not allow us to classify the tip type. Only six tanged points with DIFs retain the tip. With respect to base types, the asymmetric base type (Fig. 4[b]) much less frequently bears DIFs. The asymmetry of the concave and oblique base may suggest oblique hafting. However, the low frequency of DIFs and absence of burin-like fractures do not support that these pieces have been hafted obliquely on a spear tip. Several pieces show a DIF on their base that occurred from the proximal end (Fig. 5e, g). These DIFs can occur due to the longitudinal force from the shaft when a stone tip hits a target. This fracture pattern would have resulted from the longitudinal hafting of the tanged point to a spear tip.

Numerous tanged points from the Jingeuneul site exhibit transverse fractures with step, hinge, or feather terminations (Figs. 5g, h, and 6a, c, h, i) (Table 2). Of these, four transverse fractures show no clear temporal relationship between the fractures and intentional retouch or the lack of intentional retouch. Because transverse fractures can also accidentally occur during the blade production process, we cannot determine whether these transverse fractures were created due to impact or had already formed during the blade production process (Sano 2009). Nevertheless, 22 transverse fractures are indicated to have occurred after lateral retouch and can therefore be considered to be DIFs.

Moreover, transverse fractures found on the Jingeuneul tanged points have often been associated with spin-offs and other DIFs (Figs. 5f, and 6b, d–f). Most unifacial spin-offs are shorter than 6 mm in length and are therefore classified as non-diagnostic fractures (NDFs) (Table 2). However, these include unifacial spin-offs larger than 3 mm (half of them are over 3 mm and one spin-off is even 5.4 mm) that not never, but rarely, occur owing to production and post-depositional processes (Sano 2009). In addition, because most of the spin-offs are associated with other DIFs, it is reasonable to assume that they also occurred due to impact.

A large number of the tanged points retain only their bases (Fig. 5 (no. 5) and Fig. 6 (nos. 3–6)). Their tips were detached primarily due to transverse fractures. Of the 20 tanged points with DIFs, at least six pieces morphologically show that they lost more than half of their mass, suggesting a high-impact energy.

The number of tanged points with DIFs found at each concentration is shown in Table 5. The largest number of tanged points with DIFs ($N = 5$) was found at concentration 25. Subsequently, concentrations 3 and 4 each yield three tanged points showing DIFs. A total of four tanged points found outside of the concentrations show DIFs.

Morphometric analysis

While a considerable number of the tanged points showed DIFs, no macroscopic use-wear traces other than hunting were observed. Therefore, we currently have no evidence for other use activities of tanged points. Nevertheless, we cannot

Table 4 Ratios of samples with DIFs to total samples (samples with DIFs/total samples) according to the tip and base types

Tip Base	[1]	[2]	[3]	[4]	[5]	Broken	Total
[a]	1/10 (10%)	1/4 (25%)	2/2 (100%)	1/2 (50%)	0/0	4/14 (28.6%)	9/32 (28.1%)
[b]	0/7 (0%)	0/4 (0%)	0/2 (0%)	0/0	0/1 (0%)	2/9 (22.2%)	2/23 (8.7%)
[c]	1/3 (33.3%)	0/3 (0%)	0/1 (0%)	0/0	0/0	1/4 (25%)	2/11 (18.2%)
Broken	0/0	0/1 (0%)	0/1 (0%)	0/0	0/1 (0%)	7/26 (26.9%)	7/29 (24.1%)
Total	2/20 (10%)	1/12 (8.3%)	2/6 (33.3%)	1/2 (50%)	0/2 (0%)	14/53 (26.4%)	20/95 (21.1%)

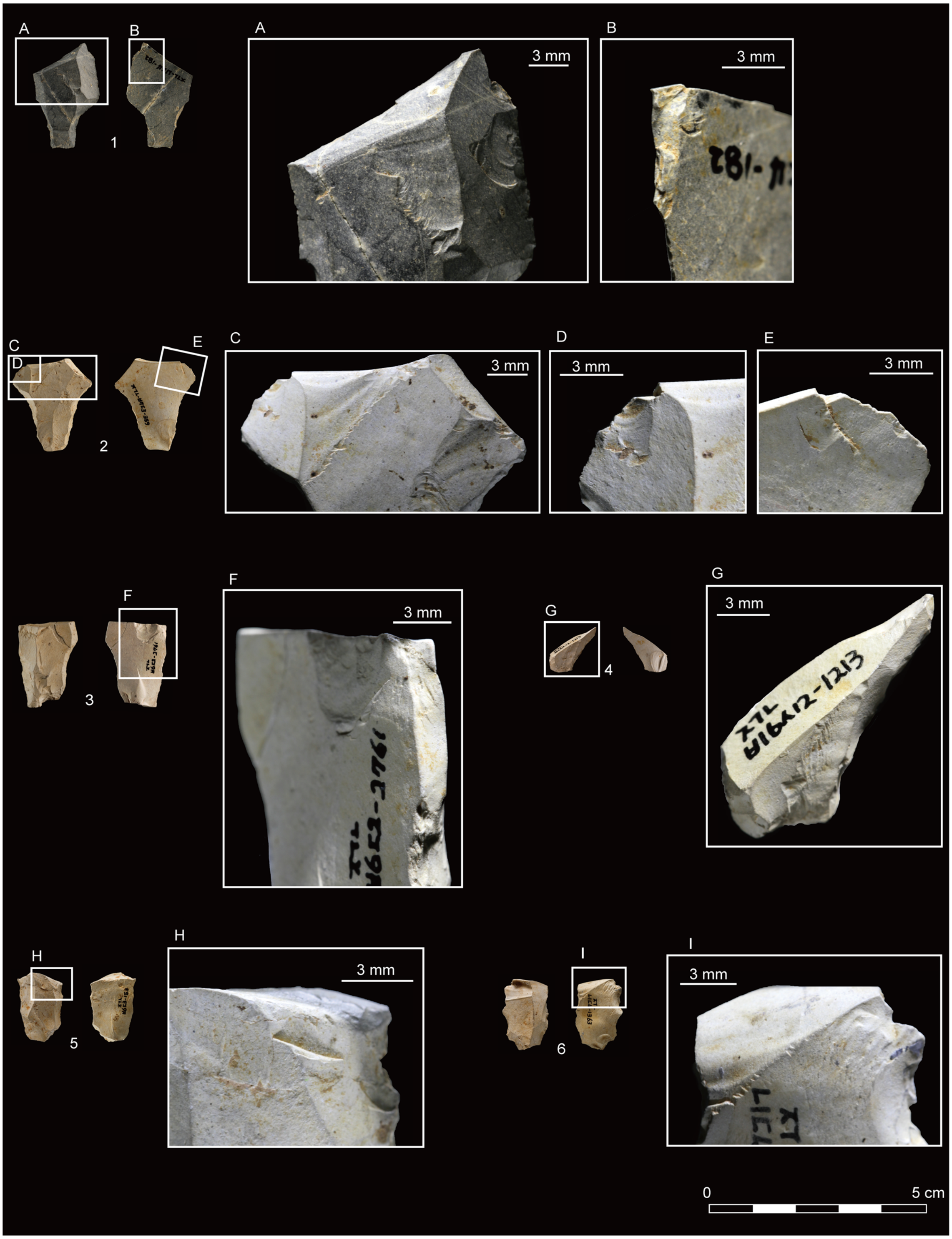

Fig. 6 Tanged points from the Jingeuneul site showing DIFs: **a** transverse fracture with feather termination and crushing on the lateral edge, **b** spin-off on the lateral side, **c** transverse fracture with feather termination, **d** spin-off on the dorsal face, **e** spin-offs on the ventral face, **f** spin-offs on the ventral face and lateral side, **g** burin-like fracture, **h** transverse fracture with step termination, and **i** transverse fracture with feather termination

exclude the possibility that the Jingeuneul tanged points without DIFs were used for activities other than hunting, because it was impossible to analyze the microwear traces due to the heavily developed patina. Therefore, we only examined the projectile capability for the tanged points with DIFs that retained the widest and thickest part of the specimens.

Table 5 Frequencies of samples with DIFs by concentration. Percentage shows the ratio of samples with DIFs to total samples from each concentration

Concentration	Number of samples with DIFs
Concentration 3	3 (23.1%)
Concentration 4	3 (50%)
Concentration 6	0 (0%)
Concentration 9	0 (0%)
Concentration 10	0 (0%)
Concentration 13	1 (100%)
Concentration 14	0 (0%)
Concentration 15	1 (100%)
Concentration 16	0 (0%)
Concentration 17	0 (0%)
Concentration 18	2 (18.2%)
Concentration 19	1 (25%)
Concentration 25	5 (20.8%)
Outside of concentrations	4 (36.4%)
Total	20 (21.1%)

First, we performed TCSA and TCSP analyses for ten tanged points that retained the widest and thickest part of the specimens and displayed DIFs. The boxplots of both the TCSA and the TCSP values of these tanged points are close to those of North American dart tips (Fig. 7). The TCSA and TCSP values are not statistically different from those of the North American dart tips (TCSA, $t = 1.094$, $p = 0.298$; TCSP: $t = -0.714$, $p = 0.479$) but are significantly larger than those of the arrowheads (TCSA, $t = 5.310$, $p < 0.05$; TCSP: $t = 5.073$, $p < 0.05$).

Because all of the tanged points with DIFs retained their bases, their neck widths were compared to those of North American dart tips and arrowheads. In contrast to the TCSA and TCSP values, the boxplot of the neck widths of the Jingeuneul tanged points with DIFs falls within the range of the neck widths of North American arrowheads but differs from those of North American dart tips (Fig. 8a). In addition, the neck widths of the Jingeuneul tanged points do not show statistically significant differences from those of the North American arrowheads ($t = 0.151$, $p = 0.881$) but are significantly smaller than those of the North American dart tips ($t = -7.540$, $p < 0.05$).

Discussion

The use-wear analysis confirmed that 20 out of the 95 analyzed tanged points from the Jingeuneul site show DIFs. Taking into account the fact that a considerable number of experimental stone tips did not leave any diagnostic impact scars (Sano and Oba 2015; Sano et al. 2016); quite a large number of the Jingeuneul tanged points must have been used as hunting weapons. Even though the results do not exclude the possibility that tanged points from other Korean sites were used differently, this study demonstrates that Korean tanged points indeed functioned as hunting armatures as has been assumed morphologically (Chang 2002; Lee and Kong 2002; Seong 2008; Lee and Jang 2011).

In addition to the high frequency of DIFs, at Jingeuneul site, numerous tanged points showed multiple DIFs. Projectile experiments with backed points indicate that a complex fracture pattern is a reliable marker for the use of mechanically assisted armatures because such multiple DIFs occurred only in spear-thrower and bow experiments (Sano and Oba 2015). Furthermore, the relatively large number of spin-offs confirmed on the Jingeuneul

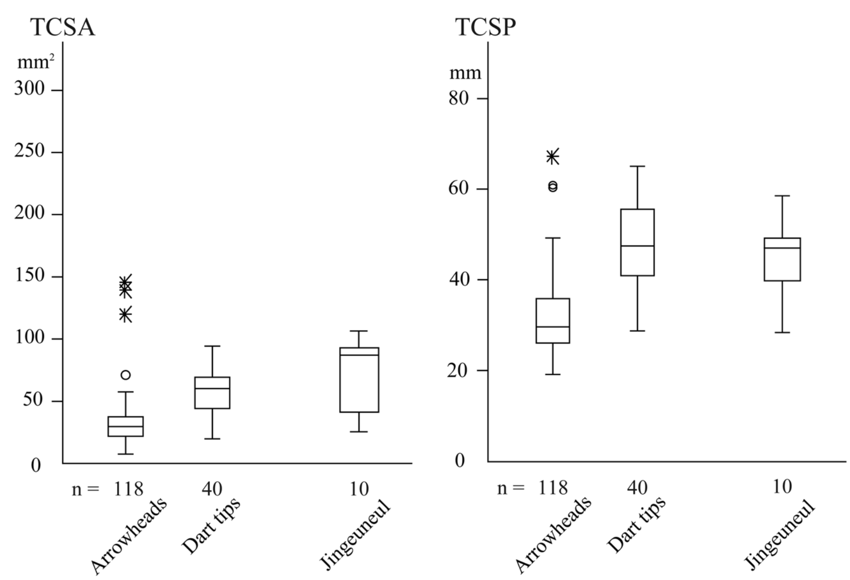

Fig. 7 Boxplots for the TCSA and TCSP values of the tanged points from the Jingeuneul site compared to those of North American arrowheads and dart tips (Thomas 1978; Shott 1997)

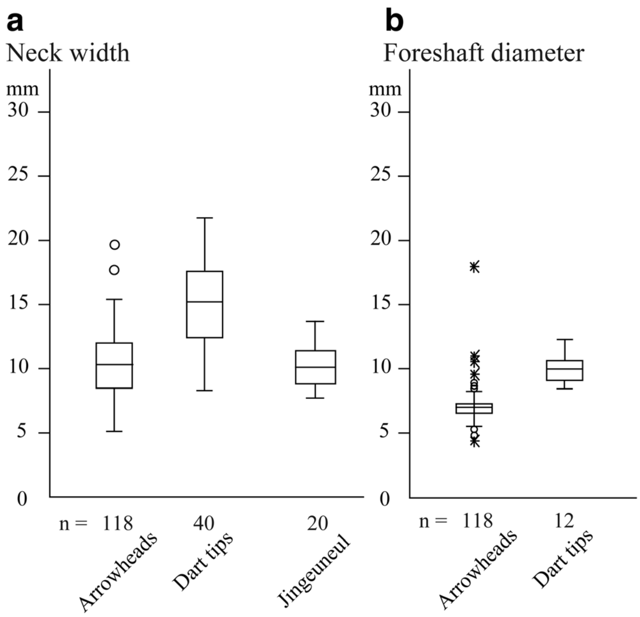

Fig. 8 Boxplot for the neck widths of the tanged points from the Jingeuneul site compared to those of North American arrowheads and dart tips (Thomas 1978; Shott 1997) and to the foreshaft diameter of the arrowheads and dart tips (Thomas 1978)

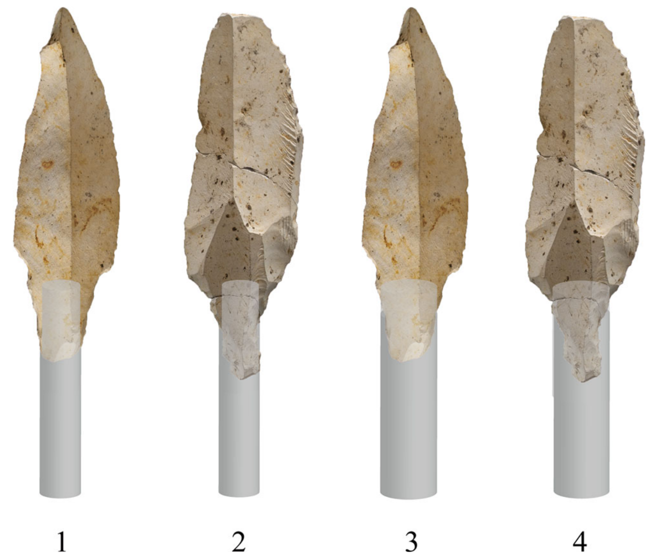

Fig. 9 Reconstructed hafting modes. Tanged points 1 and 2 are hafted into a shaft with an average diameter of North American arrow foreshafts (7.1 mm) and points 3 and 4 are hafted into a shaft with an average diameter of North American dart foreshafts (10 mm) (Thomas 1978)

tanged points could also be a sign of the use of spear-throwers or bows (Sano and Oba 2015).

A greater kinetic energy induces a higher force on the stone tips, resulting in fragmentation (Sano and Oba 2015; Sano et al. 2016). At the Jingeuneul site, a larger number of tanged point bases were recovered than other parts of the tanged points (Kim 2017). Of the pieces, six showed DIFs, suggesting that their tips were removed due to a high-impact energy.

While the TCSA and TCSP analyses suggest that the Jingeuneul tanged points are suitable for spear-thrower delivery, their neck width is more similar to that of North American arrowheads. Accordingly, the present morphometric analyses do not allow us to determine which projectile mode is most plausible. The frequency of the DIF types and the fracture formation pattern suggest that the tanged points were longitudinally mounted into the tip of a spear shaft. Based on the average values for the foreshaft diameter of North American arrowheads and dart tips (Thomas 1978), we reconstructed two types of foreshafts for the Jingeuneul tanged points (Fig. 9). Although the arrowhead foreshaft does not cover a considerable part of the base, the foreshaft diameter for North American arrowheads and dart tips is significantly smaller than their neck width (Fig. 8b). Therefore, we cannot exclude the possibility that the Jingeuneul tanged points were hafted with foreshafts as narrow as those for the North American arrowheads.

Recently, controlled projectile experiments have been performed to confirm a correlation between projectile systems and their impact trace patterns. Even though one of the authors (K. Sano) has already conducted such projectile experiments with backed points (Sano and Oba 2015) and trapezoids (Sano et al. 2016) and there have been projectile experiments with Levallois (Iovita et al. 2016) and Mousterian points (Clarkson 2016), the fracture patterns are dependent not only on the impact velocities but also on the stone tip morphology (Sano and Oba 2014). Identifying the precise delivery mode of the Jingeuneul tanged points requires controlled projectile experiments with Korean tanged points.

Nevertheless, both the impact fracture patterns and the morphometric values demonstrate that the hunting weapons of the Jingeuneul hunters were mechanically propelled and were not thrust by hand or hand-cast. The higher impact energy of their projectile system enabled them to penetrate animal targets; however, the tanged points were broken and their tips may have been embedded in the animal's body. It is ethnographically known that hunters tried to gather their arrows because the manufacture of an arrow shaft consumed more time than that of a stone point (Keeley 1982). Because stone tip bases often remained in the shaft, they would have been carried back to the camp together with the arrow shafts. Therefore, a large number of the bases of tanged points were brought back to the camp at Jingeuneul.

As mentioned earlier, the lithic assemblage at the Jingeuneul site resulted from the accumulation of at least two or more occupational remains. The exceptionally large number of tanged points and their hunting scars suggest that the Jingeuneul site was repeatedly occupied for the same purpose. Abundant debris of blade production also indicates that lithic production from blade knapping to final shaping of tanged points was conducted at this site. The intensive lithic production is especially evident at concentration 9. Interestingly, while numerous tanged points were recovered from this isolated large concentration, none of them show DIFs (Table 5). In contrast, in the areas of concentrations 3–4, the tanged points show a relatively high frequency of the DIF occurrence. A considerable number of tanged points bear DIFs at concentration 25 as well, suggesting that this isolated spot may have also been used for the maintenance of hunting weapons.

The Jingeuneul site is located in a relatively wide river terrace among the mountainous landscape of the Jinan high plateau. However, because the river terrace is north facing and is placed behind mountains, the amount of sunshine is much less than that which can be expected at a base camp. One of the narrow and long valleys around the site is called Hwal-gol, meaning bow valley, where the ethnographic hunting of animals, such as deer and wild boars, has continued up until quite recently. Conversely, abundant gravels of fine rhyolite are present on the streambed in front of the Jingeuneul site. Consequently, the Jingeuneul site was likely an optimal location for preparing hunting gear as well as hunting in the vicinity and these were the main activities there between c. 28 kcal BP and c. 20 kcal BP.

Conclusions

The tanged points from the Korean Peninsula have long been assumed to have been used as hunting weaponry. The present use-wear study first confirmed the validity of the morphologically assumed function of the tanged points. Even though no direct evidence for spear throwers or bows-and-arrows has been unearthed from East Asian Paleolithic sites, this study demonstrates that hunter–gatherers occupying the Jingeuneul site used mechanically delivered armatures, such as spear-thrower darts or bows-and-arrows.

Soon after the start of the Upper Paleolithic in Korea, early Upper Paleolithic assemblages, characterized by trapezoids, pointed blades, and edge-ground axes, suddenly appeared on the Japanese islands at approximately 38 ka (Izuho and Kaifu 2015; Morisaki et al. 2015; Sano 2016). The first hunting armatures on the Japanese islands, trapezoids, have been proven to have been mechanically projected (Sano 2016). Therefore, modern humans expanded into East Asia and likely equipped themselves with mechanical devices that allowed them to shoot their hunting armatures with much higher impact velocity; however, the organic materials have disappeared.

There are no unambiguous dated stone-tipped weapons from pre-Upper Paleolithic sites in East Asia; however, several pointed tools might have been occasionally used as hunting weapons (Park 2000). Archaic hominins lived in East Asia before the dispersal of modern humans that produced stone tools but did not mount them on their spear tips. Taking into account the current archeological evidence (Gao and Norton 2002; Lee 2006; Seong 2008; Gao 2013; Wang et al. 2012; Lee 2015b), East Asian archaic hominins likely used untipped spears, if they used hunting weapons. Stone-tipped weapons can leave a larger inner wound cavity (Wilkins et al. 2014; Salem and Churchill 2016) and mechanically assisted armatures allow humans to hunt diverse animal game at a secure long distance (Shea and Sisk 2010). The emergence of tanged points in the Korean Peninsula reflects the arrival of modern humans to East Eurasia. Modern humans expanded into East Asia with a new hunting system and obtained a significant advantage over pre-East Asians with subsistence strategies.

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