

Human-induced traumas in the skulls of the Edo people

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Abstract The purpose of this study was to survey the frequency of human-induced traumas in 1203 skulls of the Edo people. Fractures in the skull were classified as 1) keen-edged fractures, 2) slot fractures, 3) slot & burst fractures, 4) slit fractures, or 5) circular fractures. The frequency of keen-edged fractures was only 1.5%, which may reflect the social stability and peace during the Edo period. Stab marks of keen-edged fractures and slot fractures may have been caused by test stabbing by a Japanese spear. Slot & burst fractures were found in 12 skulls (1.7%), and this type of fracture may have been caused by unintentional breakage accompanying duplicated burial. Only three skulls were found to have compressed fractures, and one skull had a circular fracture, possibly caused by a gunshot by a matchlock gun. These human-induced traumas reflect the characteristics of violence and culture of the Edo period.

Key words : Human-induced, trauma, Edo, Skull, cut mark, gun shot wound.

Introduction

Human-induced traumas to human skeletal remains have been reported among the ancient Japanese (Suzuki, 1956; Kawagoe, 1975; Morimoto, 1987; Morimoto and Hirata, 1992; Ohtani and Baba, 2001; Hirata *et al.*, 2004; Saiki *et al.*, 2006; Nagaoka and Abe, 2007; Dodo *et al.*, 2008; Nagaoka *et al.*, 2010; Sakaue, 2010), and they cast an interesting light on the war, violence, and cultural behavior of ancient society.

Although the number of human skeletal remains of the Edo period is larger than those of other periods in Japan, reports on human-induced traumas are very limited. One is the Dr. Kawagoe's essay published in 1975, which noted that about 20 skulls showed the cut marks out of around 2000 skulls without detail information. Another study by Ohtani and Baba (2001) reported human skulls unearthed from the Kozukahara execution site. They studied the frequency of "bone damage" and identified seven kinds of human-induced traumas in 436 skulls from the Edo period, of which 104 were unearthed from the Kozukahara execution site. They reported

that 86 skulls (42 of which were from the Kozukahara execution site) showed bone damage, and that "linear damages by instruments with a blunt edge" and "stab wound by a flat instrument" were frequently found among the Kozukahara execution materials (28 and 13 skulls, respectively). Because that intensive study was focused on the morphological characteristics of the skulls found at the Kozukahara execution site, the sample size of the reference groups were limited and the detailed classification of bone damage was not applicable to skulls unearthed from other sites.

The purpose of the present study was to macroscopically examine human-induced traumas in skulls unearthed from sites of the Edo period and to investigate the underlying causes of these traumas considering the socio-cultural background of the Edo period.

Materials and Methods

All materials used in this study are stored in the Human Osteological Collection at the Department of Anthropology, National Museum of Nature and Science, Tokyo. Skulls were used

in this analysis if they met the following criteria: almost no weathering damage on the skull surface, the presence of an almost complete skull with facial bones with or without the mandible, and having the eruptions of the upper third molar and/or closure of spheno-occipital synchondrosis. A total number for investigation was reached up to 1203 unearthed from 37 archaeological sites. All sites used in the report by Ohtani and Baba (2001) were included. The archaeological

sites and the number of individuals for this study are presented in Table 1.

In this study, a fracture in which the breakage was the same color as the surrounding bone was considered to be perimortem (Sauer, 1998; Ortner, 2008). Human-induced traumas were defined as traumas caused by physical impact on one's head caused by another human being with an instrument. Basically, human-induced traumas were discriminated on the basis of morphological

Table 1. Frequencies of human-induced traumas in the Edo samples

	N	Keen- edged	%	Slot	%	Slot & Burst	%	Slit	%	Compressed	%	Circular	%	Any traumas	%
Enouji	17														
Hachobori Keiyouzen construction	2														
Hachyobori 1 chome	1	1	100.0			1	100.0							1	100.0
Hachyobori 2 chome	1					1	100.0							1	100.0
Hachyobori 3 chome (first)	12														
Hachyobori 3 chome (second)	52	2	3.8											2	3.8
Hosshoji ato (first)	51	1	2.0											1	2.0
Hosshoji ato (second)	4														
Higaskannda (first)	3														
Honbutuji (No. 21 site of Sumida ku)	42			1	2.4									1	2.4
Hongo 5 chome	15	3	20.0											3	20.0
Honryo 2 chome	10			1	10.0									1	10.0
Honseiji	23	1	4.3							1	4.3			2	8.7
Houkouji (No. 42 site of Shinryuku ku)	5														
Housenji	5														
Ikenohatashicikencho	296	3	1.0			5	1.7	3	1.0					10	3.4
Iwamotocho	7														
Jitouinn (first)	3														
Jitouinn (second)	1														
Jyousinji	116			1	0.9	6	5.2			1	0.9			8	6.9
Keiinnji (No. 57 site of Taitou ku)	12														
Kikusakasita	4														
Kozukahara execution	75	5	6.7	7	9.3	6	8.0	4	5.3					16	21.3
Mansyouji ato	3														
Minamisenjyu 2	9									1	11.1			1	11.1
Minamisenjyu 3	18														
Narihira 3 chome	8	1	12.5											1	12.5
Narihira 5 chome	12														
Ryuukokuji (No. 36 site of Shinryuku ku)	2														
Ryuusenji (No. 31 site of Shinryuku ku)	11														
Shyoukenji	77													1	1.3
Sitayadouboucho	14														
Suugenji	231					2	0.9	1	0.4					2	0.9
Syujyouji (No. 64 site of Shinryuku ku)	3														
Toritu Ueno high school	19														
Yanakamisaki cho	16														
Yusima 4 chome	23	1	4.3									1	4.3	2	8.7
Total	1203	18	1.5	10	0.8	20	1.7	8	0.7	3	0.2	1	0.1	53	4.4

This table shows the number of individuals having each type of fractures and frequencies in each site.

similarity to “sharp force trauma (cut mark, shop mark, saw mark)”, “blunt force trauma”, and “gunshot wound” that were reported and defined in previous works in forensic anthropology (Berryman and Symes, 1998; Arbour, 2008; Boutros-Ghali, 2008; Berryman *et al.*, 2012). In general, human-induced traumas are characterized by linear, nearly linear, partially linear, or nearly circular configurations in the skull. These features are rarely found in bone breakage of irregular shape, caused by animal-induced damage, pathological changes, or environmental damage of weathering or diagenesis. Healed fractures were excluded in this study.

After investigating all fractures in Edo skulls, human-induced fractures were classified into five types as follows on the basis of their morphological characteristics.

1) Keen-edged fractures

This type of fracture, also called “sharp force trauma” in the previous works, indicates a bone fracture or defect made by a keen-edge instrument (Boutros-Ghali, 2008). The diagnostic criteria for this kind of trauma are “linearity”, “a well-defined clean edge (margin of bone defect)”, and “a flat, smooth, polished cut surface” on macroscopic observation (Figure 1; Boylston, 2000).

Among the Edo samples, two kinds of keen-edged fractures were recognized according to the usage of the instrument: cut mark and stab

mark. A cut mark was made by the keen-edge of an instrument struck perpendicularly to the surface of the skull (Figure 2), while a “stab mark” was made by the sharp end of an instrument inserted into the skull (Figure 3). Thus, stab marks were always accompanied with well-defined clean margins and a smooth cut surface around the defect.

2) Slot fractures

This type of fracture resembles the “slot fractures” reported by Weber and Czarnetzki



Fig. 1. Example of a keen-edged fracture (sharp force trauma).

Three keen-edge fractures (①~③) can be seen in the left parietal bone of “24/455/C1” of the Ikenohatahikichencho site. A bracket indicates the linear shape of the fracture, the black arrows indicates the “well-defined clean edge (margin)”, and the white asterisk indicates “the flat, smooth, polished cut surface”.

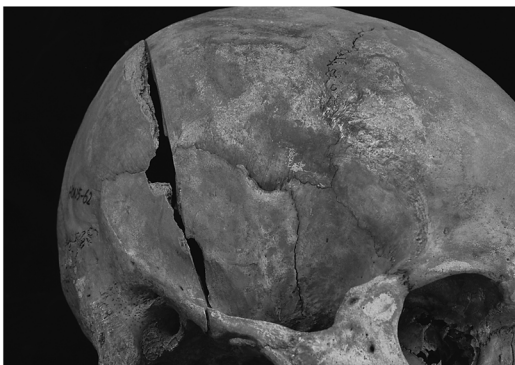


Fig. 2. Keen-edged fracture (cut mark) in the Edo samples.

These pictures show the “cut marks” in “No. 62” of the Hongo 5 chome site (left) and “16/565/B3” of the Ikenohatahikichencho site (right).

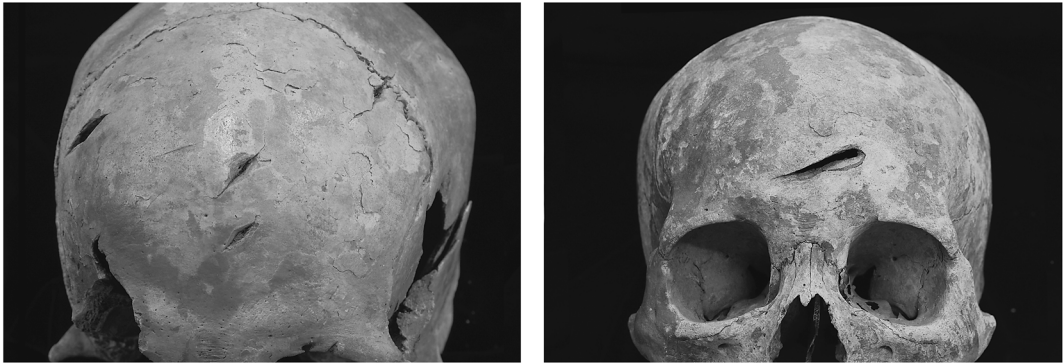


Fig. 3. Keen-edged fracture (stab mark) in the Edo samples.

These pictures show the “stab marks” in “Fukabori ikkatu ②” of the first Hosshoji ato site (left) and “No. 52” of the Kozukahara execution site (right).



Fig. 4. Slot fracture in the Edo samples.

These pictures show the slot fractures in “No. 83” of the Kozukahara execution site (left) and “No. 128” of the Jyousinji site (right).

(2001) and Boutros-Ghali (2008) with the exception of the lack of a smooth cut surface. This defect is characterized by a triangular or narrow rectangular shape, which may reflect the cross section of the instrument, and an opening to the brain cavity (Figure 4). Therefore, this trauma may be a result of injury by a metal instrument lacking a keen edge. The diagnostic criteria for this type are “near linearity”, “partially clean margin of the bone defect”, “lack of a smooth cut surface”, and “penetration of the cranium”. This fracture can be distinguished from a stab mark mentioned above by the lack of well-defined clean margins and a smooth cut surface.

3) Slot and burst fractures (slot & burst fractures)

This type also resembles the “chop marks” described by Boutros-Ghali (2008) but lacks a smooth cut surface. Although the shape of the bone defect of this fracture can appear irregular, there are partially straight margins that can be regarded as part of the “slot fracture” mentioned above (Figure 5). As Boutros-Ghali (2008) indicated, the irregular defect on the bone may be a result of many fractures caused by striking and/or levering upon removal with a long or thick bladed instrument such as a machete, an axe, or a cleaver. In this paper, this fracture is thought to be caused by stronger and/or heavier striking or stabbing than

those resulting from the “slot fracture” but with the same kind of metal instrument lacking a keen edge. The diagnostic criteria are “irregular defect”, “partially linear margin”, “lack of a smooth cut surface”, and “penetration of the cranium” (Figure 6).

4) Slit fractures

This type of fracture is characterized by linear depression without clean margins and a smooth cut surface and no penetration to the cranial cavity (Figure 7). In the Edo samples, this trauma is also thought to have been caused

by relatively weaker and/or lighter strike or stab than those of the “slot fracture” and “slot & burst fracture” with the same kind of instrument lacking a keen edge. The diagnostic criteria are “a linearity depression without penetration” and “lack of a smooth cut surface”.

5) Compressed fractures

This fracture is a type of “blunt force trauma” resulting from a broad instrument such as a hammer, brick, or pipe (Berryman and Symes, 1998; Arbour, 2008). In this study, compressed fractures were characterized by a circular inward defect with some fracture lines surrounding the defect (Figure 8).

6) Circular fractures

This fracture is characterized by an almost perfect circular defect (Figure 9), resembling a “gunshot wound”, which resulted in a circular defect on the outer surface and a beveling defect on the opposite side of the bone if the trajectory of the bullet was perpendicular to the bone surface (Berryman and Symes, 1998). Among the Edo samples, only one skull showed this unique defect and will be discussed in detail later in the text.

The sex of individuals was determined by cranial features (Sakaue and Adachi, 2009). All statistical analyses were conducted using Microsoft Excel 2010 (Microsoft Co., Ltd.) and Tukey’s wholly significant difference (WSD) tests were performed for post hoc comparison between pro-

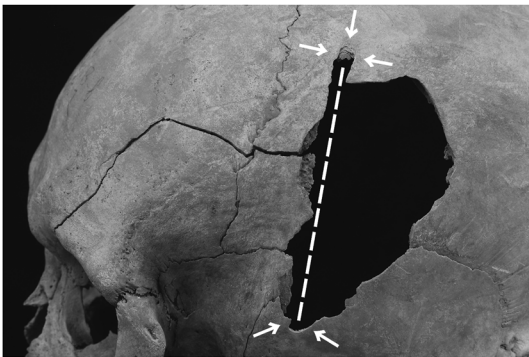


Fig. 5. Example of slot & burst fracture.

This picture shows the slot & burst fracture of “67/721/B8_part1skull ③” unearthed from the Ikenohatahickencho site. A dotted line indicates the hypothetical “slot fracture”. No well-defined clean margins or smooth cut surface are seen around the areas indicated by the white arrows.

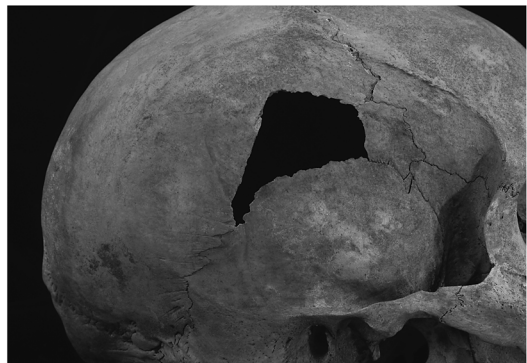


Fig. 6. Slot & burst fracture in the Edo samples.

These pictures show the slot & burst fractures in “No. 535a” of the Suugenji site (left) and “No. 9” of the Jyousinji site (right).



Fig. 7. Slit fracture in the Edo samples.

These pictures show the slit fractures in frontal bone of “No. 14” of the Kozukahara execution site (left) and right zygomatic process of the frontal bone of “No. 337” of the Suugenji site (right).

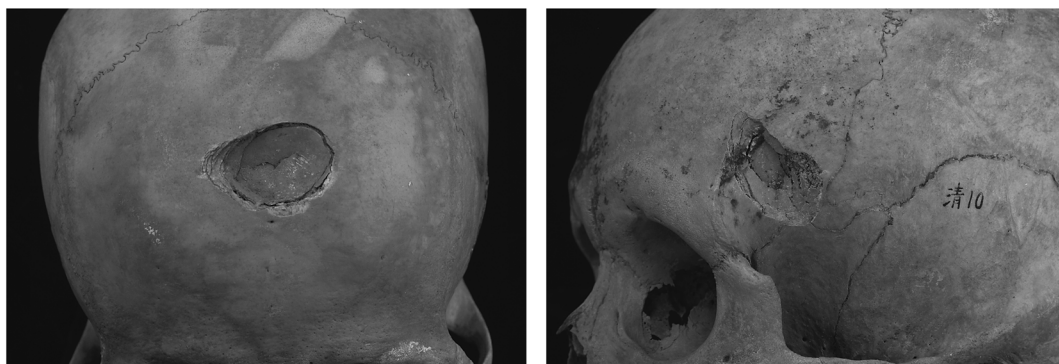


Fig. 8. Compressed fracture in the Edo samples.

These pictures show the compressed fractures in “No. 3” of the Minamisenjyu 2 site (left) and “No. 10” of the Honseiji site (right).

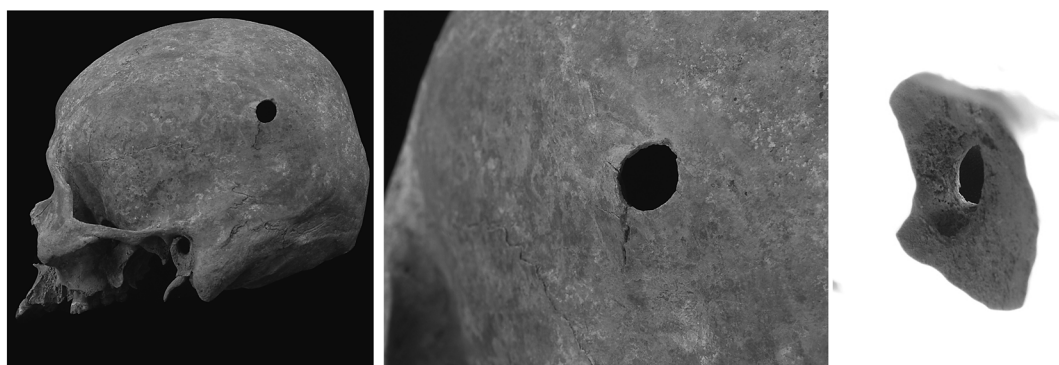


Fig. 9. Circular fracture in the Edo samples.

The left picture is the overview of “No. 43” of the Yushima 4 chome site, the middle picture is an enlarged view of the circular fracture, and the right picture is the inner beveling fracture from the view of the left orbital cavity.

portions according to Ryan's procedure (1960). Statistically significant levels in this paper were at 5%.

Results and Discussion

The frequencies of each fracture are presented in Table 1. The frequency of skulls with any human-induced trauma was 4.4% (53 out of 1203), which seems to be low. However, it was not sure whether this frequency was actually low or not because there was no reports on the frequencies of all human-induced traumas in another city or other population for comparison. Although the actual number of victims of murder and injury in the capital Edo was unknown, Ishii (1964) estimated that 427 executions took place in the capital Edo from 1862 to 1865 based on official documents. 427 executions included the criminals charged with other crimes but murder, so about 100 victims were roughly thought to be killed in conflict for a year in the capital Edo. The estimated population of the capital Edo in the late Edo period was 788,000 people (Chandler 1987). The annual murder rate was therefore calculated to be 0.014%. the frequency of human-induced traumas in this study appeared to be high, suggesting that not all human-induced traumas resulted from conflict.

Hereafter, each type of fracture resulting from human-induced traumas in the Edo samples will be discussed.

Keen-edged fractures

Of the 1203 Edo samples, 18 (1.5%) skulls showed a keen-edged fracture. All individuals but one were determined to be male (Table 2). The frequency of keen-edged fractures varies depending on the archaeological sites: five from the Kozukahara execution site, three from the

Ikenohatashicikencho site, three from the Hongo 5 chome site. It was reasonable that a relatively large number of individuals were found at the Kozukahara execution site, a place where criminals were punished to death during the Edo period.

Among keen-edged fractures, twelve individuals showed cut marks. "Gashes" that penetrated both the external and internal laminae defined by Hirata *et al.* (2004) were found in six individuals, of which five individuals were intentionally attacked by someone with a keen-edged weapon (for example, Japanese sword) in battle; the remaining one individual with "tameshi-giri" wounds was likely the executed person (No. 16 of the Yushima 4 chome site: Sakaue, 2010). Seven individuals had stab marks to the skull; of these, four were from the Kozukahara execution site, one from the Yushima 4 chome site, one from the 1st Hosshoji ato site, and one from the Hongo 5 chome site. Among them, four individuals had multiple stab marks (for example, eight triangular marks in the skull of the 1st Hosshoji ato site), and 12 of the 19 stab marks were focused on the frontal bone while no marks were found on the occipital bone. Thus, it is possible that someone with a keen-edged weapon stabbed several times without the intent to kill. As Sakaue (2010) mentioned, these skulls might represent subjects used for testing of a Japanese spear ("*Tameshi-zuki*").

The frequencies of weapon-related traumas of the Edo sample and those of the Seiyokan site, Yuigahama Chusei Shudan Bochi site, Yuigahama-minami site, and Zaimokuza site in Medieval Japan and results of Tukey's WSD tests were shown in Table 3 (Suzuki, 1956; Hirata *et al.*, 2004; Nagaoka *et al.*, 2010). The frequency in the Edo samples was significantly lower than in the Seiyokan site and Zaimokuza site. Suzuki

Table 2. The number of individuals showing a human-induced trauma according to sex

	Keen-edge	Slot	Slot & Burst	Slit	Compressed	Circular
Male	17	9	16	4	2	1
Female	1	1	4	4	1	0

Table 3. Comparison of frequencies of sharp force trauma between the Edo and the medieval period

	Edo	Seiyokan ^{*1}	YCSB ^{*2}	YM ^{*3}	Zaimokuza ^{*4}
Number of individuals	1203	91	592	667	283
Number of sharp force trauma	18	6	8	4	186
Frequency (%)	1.5	6.6	1.4	0.6	65.7
Results of Tukey's WSD test					
Seiyokan	*				
YCSB		*			
YM		*			
Zaimokuza	*	*	*	*	

^{*1} Nagaoka (2010).

^{*2} Hirata *et al.* (2004). YCSB: Yuigahama Chusei Shudan Bochi site.

^{*3} Hirata *et al.* (2004). YM: Yuigahama-minami site.

^{*4} Suzuki (1956) and Hirata *et al.* (2004).

“*” means statistically significant difference between frequencies at 5% level.

(1956) suggested that the skulls unearthed from the Zaimokuza site were of victims of a battle of the Genko War (1331–1333), and Nagaoka *et al.* (2010) pointed out that the characteristics of sharp force trauma found on skulls of the Seiyokan site suggested the prevalence of violence in the medieval period. In contrast, the low frequency of keen-edged fractures in the Edo samples might reflect the stable and peaceful social situation of the Edo period, especially in the capital Edo.

Slot fractures

The number of skulls with a slot fracture was 10 (0.8%). All individuals but one were determined to be men (Table 2). Seven of the 10 skulls were unearthed from the Kozukahara execution site, which represents a relatively higher frequency than in other sites. Some, but not all of these traumas were caused by an attack with a dull-edged weapon during conflict. In the Edo period, criminals had been dragged to the Kozukahara execution site alive and executed by decapitation using a Japanese sword, crucifixion using a Japanese spear, or burned to death. In other cases, the decapitated head of a criminal executed in prison was carried to the execution site for public display (Ishii, 1964). Thus, a fracture on the skull unearthed from the Kozukahara execution site may have occurred after execution, meaning that assault with a dull weapon at

the execution ground was unlikely. Test stabbing with a Japanese spear was most likely to cause the slot fracture in the skull unearthed from the Kozukahara execution site as well as the “stab mark”. However, the underlying reason for the lack of a straight linear defect and smooth cut surface if the slot fractures were made by test stabbing remains unknown. Further studies with a larger number of cases are needed to clarify the cause of this type of fracture.

Slot & burst fractures and slit fractures

Among the 1203 Edo skull samples, slot & burst fractures were most common (20 of 1203; 1.7%). The frequency of slit fractures was 0.7% (8 of 1203). These two types of fractures were commonly observed fractures in women (Table 2).

These fractures might have resulted from intentional attack on the skull with a dull-edged tool, resulting in instant death because no sign of healing was observed and the breakage opened into the cranial cavity. However, these fractures were also observed in skulls from the Kozukahara execution site (n=6), where death by dull-edged weapons did not occur. It was therefore doubtful that all of these fractures resulted from human attack during conflict. Another interpretation of these fractures was unintentional breakage caused during grave digging. As Tanigawa (2004) mentioned, duplicated burial, which



Fig. 10. "Hito no issyou, Boketuhori (human development, gravedigging)"

This painting was drawn by Keiga Kawahara in the Edo period and is stored at the Nagasaki Museum of History and Culture.

meant that a person was buried additionally and unintentionally in a grave where someone already had been buried, was very common in the Edo period. It was likely that a gravedigger dug up a new grave by using an agricultural instrument, such as a hoe, and this resulted in the unintentional breakage of the bone of the person who was already buried there. An agricultural instrument like a hoe was commonly used for grave digging and did not have a keen edge like that of a Japanese sword. It was probable that the powerful stroke of agricultural instruments caused large breakages on the skull, resembling that of a slot & burst fracture. An interesting painting drawn by Keiga Kawahara (1786?–1860?), a Japanese style painter who lived in Nagasaki in the late Edo period, is shown in Figure 10. This painting, entitled "Hito

no issyou, Boketuhori (human development, gravedigging)" depicts three people digging a grave with hoes and hitting a skull. While this scenery may be an exaggerated expression of reality, such incidents may have occurred in the capital Edo, which was a highly populated city in those times, with many people buried in a narrow cemetery.

In this study, the seven skulls with slot & burst fractures and/or slit fractures were able to be examined whether they were excavated from duplicated burial or not with their archaeological reports. Three individuals ("73/871/B8" sample of the Ikenohatashickencho site, "No. 337" (Figure 7) and "No. 535a" (Figure 6)) of the Suugenji site were in a duplicated burial, while three were not confirmed because these skulls were excavated in a lump, and one was not disrupted by

another burial (Taito-ku Ikenohata-shichikencho Iseki Chosa-kai, 1997; Taisei Engineering Co., Ltd, 2005). In addition, the skulls of the Kozukahara execution site were apparently of a secondary burial because 104 skulls and three mandibles were confined into a circular wooden coffin measuring 1.0 m in diameter and 1.5 m in depth. These facts indicated that slot & burst fractures might be caused not only in conflict but also by duplicated burial.

Compressed fractures

Compressed fractures were found in only three (0.3%) of the 1203 skulls, with two individuals identified as men and one as a woman (Table 2). All compressed fractures occurred on the frontal bone. None of these fractures were accompanied by a radiating fracture line originating from the impact point by blunt force trauma when bones retain their elasticity (Berryman and Symes, 1998). Therefore, it was uncertain whether these fractures were made at perimortem in the Edo samples analyzed in this study. Like in slot fractures, it will be necessary to investigate a larger number of cases in order to clarify the underlying causes of compressed fractures.

Circular fractures

A circular fracture was identified in only one individual in this study (Figure 9). The diameter of the defect was 10.2 mm in the major axis and 9.8 mm in the minor axis. Similar to a gunshot wound, this fracture showed a beveling defect internally and a small radiating fracture, but no "exit wound" was found in this case. This indicated that the bullet did not have enough energy to penetrate the whole skull, which is a common finding among cases of firearm shots to the skull in modern forensic cases (Smith *et al.*, 1987). Unfortunately, no bullet fragment or fractures on the inner surface of the cranial cavity were found.

In the Edo period, there was a matchlock gun that was widely used for hunting wild animals causing agricultural damage (Tukamoto, 1993). The caliber of such matchlock guns varied from

8.7 to 40.0 mm, and guns within a caliber range of 8.7–11.8 mm were called "Kozutu (small barrel)", which were commonly used in the Edo period. Thus, it was possible that this circular fracture was a result of a gunshot with a Japanese matchlock.

Conclusion

In this paper, human-induced traumas of 1203 skulls from the Edo period were investigated. The frequency of skulls showing a keen-edged fracture was 1.5%, which is significantly lower than in skulls found at the Seiyokan site and Zaimokuza site in Medieval Japan. This difference in incidence may reflect the social stability and peace of the Edo period. The stab marks of keen-edged fractures and slot fractures may be caused by the test stabbing of a Japanese spear. Slot & burst fractures were noted in 12 skulls (1.7%), which may represent unintentional breakage accompanying duplicated burials. In addition, three skulls were found to have compressed fractures, while one skull had a circular fracture possibly caused by a matchlock gun. These human-induced traumas reflect the characteristics of violence and culture in the Edo period.

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