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# Patterns of Trapeziometacarpal Articular Vartilage Wear in Japanese Cadavers: What Can Be Expected?

**Tomonori Sato[1], Kyohei Kawada[1]**

[1]Department of Physical Therapy, Tokoha University, Shizuoka, Japan

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**ABSTRACT**

**Introduction:** the purpose of this study was to put forth hypotheses regarding possible wear patterns of the articular cartilage of the trapeziometacarpal (TMC) joints in Japanese cadavers. The TMC joint is frequently affected by osteoarthritis (OA), which is associated with degeneration of the articular cartilage. Detailed knowledge about the wear locations of the articular cartilage is important to obtain a clearer understanding of the etiology of the TMC OA and better manage the condition. This article presents an overview of the anatomy, biomechanics, and wear locations of the articular cartilage of the TMC joint. We further discuss "what might be expected in future studies in Japanese cadavers in relation to the wear patterns of the articular cartilage of the TMC joint."

**Keywords:** Anatomy; Cartilage; Degeneration; Trapeziometacarpal joint.

## Introduction

OA is associated with degeneration of the articular cartilage. The severity of degeneration of the articular cartilage varies depending on the age, sex, life style etc., of the subjects[1]. For example, progression of cartilage degeneration can be advanced due to the repetition of movement in daily activities by which specific wear patterns of the cartilage become more noticeable[2,3].

The TMC joint is located at the base of the thumb. It is known to be susceptible to osteoarthritis, with a prevalence in ranged of 7% to 93% in men, and 15% to 100% in women[4-6]. Osteoarthritis of the TMC (TMC OA) can be debilitating, on account of joint pain, joint hypermobility and, degeneration, narrowing of the joint space width, subluxation, reduced grip strength and decreased ability to perform daily activities[7,8]. Both conservative treatments and surgical procedures have been used for the management of TMC OA. However, no procedure has been established as being proven superior to the others, furthermore no curative treatment has been established for TMC OA[8-11]. Thus, it is considered important to prevent or the delay development of TMC OA.

Although a number of studies have described the typical wear locations on the joint surface, which result of joint degeneration, the detailed wear locations and, wear patterns of the articular cartilage of the TMC joint remain obscure, as they differ depending on the subjects studied and methodologies used[12-19]. A good understanding of the specific wear patterns of the TMC joint is essential to elucidate the etiology of TMC OA, and to devise preventive measures to minimize wear of the TMC joints resulting from wear daily repetitive activities.

In this review, we describe the anatomy, mechanics, and wear locations of the articular cartilage of the TMC joints, based on which we propose hypotheses to deduce specific wear patterns of the TMC joints in Japanese cadavers.

## Anatomy and Mechnics

### Anatomy

The TMC joint consists of an articulation between the base of the first metacarpal and distal aspect of the trapezium. The articular surface of the trapezium shows a concave curve in palmar-to-dorsal direction and a convex curve in the radial-to-ulnar direction[20]. Its dorsal articular facet is significantly less deep than its ulnar-volar facet[21]. The bone ends comprising the TMC joint possess concave and convex curves that fit into each other- such joints are called saddle joints. This configuration of the TMC joint allows for a great range of motion of the thumb as well as enables the thumb movements[22].

Several studies have been conducted to investigate if there might be differences in the articular shape of the TMC joint between women and men[13,23-27]. Studies using stereophotogrammetry in older cadavers have described that the articular surfaces are less congruent and shallower in women than in men[13,23]. Less congruent surfaces likely experience reduction of the contact area and thus increase in contact stresses. In contrast, more recent studies using CT images in younger and older subjects have shown no significant differences of the articular shape between women and men[24-27]. One possible explanation could be different ages of the subjects studied.

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A limited study has reported on the thickness of the articular cartilage of the TMC joint [13,14]. In this study, Xu *et al*[13] investigated the thickness of the articular cartilage in cadavers showing osteoarthritic changes, and reported that the articular cartilage is thinner in women is than in males (women: 0.64 ± 0.30 mm over the articular surface of the trapezium and 0.66 ± 0.27 mm over the articular surface of the metacarpal bone; men: 0.83 ± 0.21 mm over the articular surface of the trapezium, and 0.80 ± 0.18 mm over the articular surface of the metacarpal bone). Koff *et al*. also performed a cadaveric study[14] and they reported that the thickness of the articular cartilage over the trapezial surface was 0.8 ± 0.2 mm and that over the metacarpal surface was 0.7 ± 0.2 mm; however, they did not compare the thickness of the articular cartilage between women and men.

**Mechanics**

The TMC joint allows flexion and extension, palmar abduction and adduction, medial rotation (pronation) and lateral rotation (supination) as well as opposition of the thumb. The range of motion is 27˚ to 53˚ for flexion-extension, 42˚ to 67˚ for abduction-adduction, and 10˚ to 21˚ for medial rotation-lateral rotation[28-30].

During flexion/extension, the base of the first metacarpal bone moves in the plane of convexity of the trapezium. The articular surface of the first metacarpal bone moves in a volar direction relative to the articular surface of the trapezium. During the abduction/ adduction of the thumb, the base of the first metacarpal bone moves in the plane of concavity of the trapezium, while the articular surface of the first metacarpal bone moves in the radial direction[20,31].

Studies that investigated the joint contact areas have reported a central contact region in the neutral position, volar-radial contact region in flexion, abduction, adduction, and dorsal-radial contact region in extension[20,32,33]. On the other hand, inconsistent findings have been reported in relation to the central-volar contact region during abduction and dorsal-radial contact region in adduction, and dorsal-ulnar contact region in extension[23,30], as another study revealed that the contact regions of the trapezium in opposition were on the radial, volar, and ulnar side[34].

Schneider *et al*. studied the locations of peak stress in the TMC joint during pinching, grasping, and jar lid twisting, and also compared them between women and men[35]. Men showed consistent findings, wherein the peak contact stress was located in the central to radial region during pinching, grasping, jar lid twisting, while women showed variations: the peak stress location was the central region during pinching, radial volar region during grasping, and the central volar region during jar lid twisting[35].

**Wear Locations of the Articular Cartilage**

Wear locations of the articular cartilage of the TMC have been reported by numerous studies (Table 1)[12-19], Most of these studies simply classified the joint surfaces

**Table 1.** Wear locations of the TMC joint.

| Author (year) | Specimens | Methods | Description of the Wear locations |
|---|---|---|---|
| Pellegrini (1991)[12] | 27 specimens (TMC arthritis) | Gross dissections using methylene blue staining | Degeneration began in the volar region of the metacarpal bone and the trapezium. Eburnation was found in the volar region. |
| Xu (1998)[13] | 46 cadavers (21 female, 25 male) | Gross dissections | Less wear of the dorsal-ulnar region on the trapezium, and less wear of the dorsal region on the metacarpal bone were found. |
| Koff (2003)[14] | 104 fresh cadavers (41 female, 63 male) | Gross dissections | Degeneration starting in the radial region of the metacarpal bone had progressed to the volar region. Significant wear on the dorsal-radial region of the trapezium, with progression to the volar region. |
| Nufer (2008)[15] | 15 surgical specimens (radiologically and clinically diagnosed OA) | Micro-CT | Microstructural osteoarthritic change was found in the radial region of the trapezium. |
| Nortwick (2013)[16] | 36 surgical specimens | Micro-CT | Eburnation in the radial and volar region of the trapezium. |
| Zhang (2013)[17] | 5 cadavers (1 female, 4 male) | Arthroscopy and gross dissections | Volar and dorsal radial wear was reported in the trapezium and metacarpal bone as the preferential location. |
| Gómez (2015)[18] | 25 cadavers (14 female, 11 male) | Gross dissections | Degeneration starting in the radial region of the metacarpal progressing to the volar region. |
| Miyamura (2019)[19] | 19 cadavers | 3-D models created with a laser scanner | Degeneration in the volar region of the metacarpal, with even degeneration throughout the articular surface of the trapezium. |

into four quadrants to examine cartilage degeneration: dorsal-radial, dorsal-ulnar, volar-radial and volar-ulnar aspects. Unlike in previous studies[2,3], these studies have not discussed the detailed wear locations of the articular cartilage[12-19]. Furthermore, the differences in the wear locations between women and men remain unclear. Wear locations reported by previous studies are summarized in Figure 1; even though the findings of previous studies are not completely consistent, the reports suggest that cartilage degeneration most commonly occurs on the volar side.

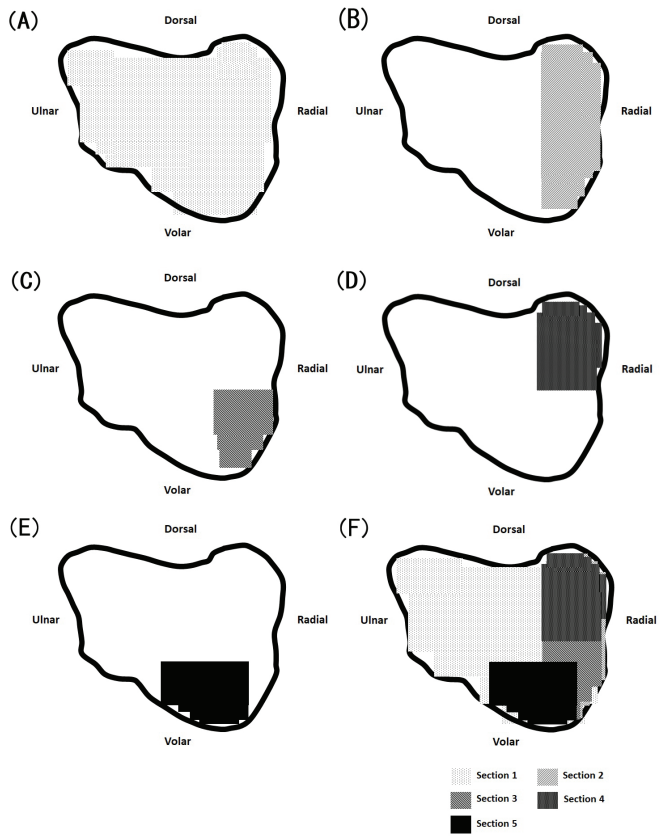


**Figure 1.** Wear locations of the articular cartilage over the articular surface of the right trapezium. (A) Section 1 shows the areas reported by one study[19]: entire surface. (B) Section 2 shows the areas reported by three studies: radial region[14,15,17]. (C) Section 3 shows the areas reported by four studies: radial-volar region[13-15,19]. (D) Section 4 shows the areas reported by five studies: radial-dorsal region[13-15,17,19]. (E) Section 5 shows the most common areas reported by six studies: volar region[12-15,17,19].

## Hypothesis

Previous studies of the wear locations of the articular cartilage of the TMC joint have been performed from different standpoints using different methodologies as compared to previous studies of the patellofemoral joint[2,3]. However, there are similarities between the TMC joint and the patellofemoral joint, including common areas of joint degeneration and association of the wear patterns with different or unique life style (Western life style vs Asian life style). Therefore, we put forward hypotheses about expected results and patterns of TMC articular cartilage wear based from similar standpoints to our previous studies.

First, epidemiological studies have been conducted to compare the radiographic prevalence of TMC OA between Asian populations and Caucasians. According to these studies, the prevalence of TMC OA is lower in Asian populations than in Caucasians[17,36]. However, there are no reports of anatomical studies conducted to compare the wear locations of the articular cartilage and/or wear patterns of the articular cartilage between Japanese and Western populations. Furthermore, no studies of any type that make comparison between Japanese and Western populations possible have been performed. Based on the findings of aforementioned epidemiological studies, we expected that our studies, be performed in Japanese cadavers, would reveal less severe degeneration of the TMC joint articular cartilage than Caucasians. Our previous study of the patellofemoral joint, which showed more severe degeneration of the articular cartilage of the femur in Japanese cadavers compared to Caucasians cadavers, lends support to this hypothesis. The results of our study were consistent with the results of the epidemiological studies suggesting a higher incidence of wear in Asian populations than in Western populations.

Secondly, sex differences of the wear locations of the articular cartilage have been identified. One previous cadaveric study showed that severe degeneration was observed more frequently in female than in male cadavers[13]. A previous epidemiological study reported a higher prevalence of TMC OA in women than in men[37], lending support to the results of the cadaveric study revealing more severe degeneration in female than in male cadavers. The reason for the more frequent occurrence of TMC OA in women are significantly less congruent than those in men[13,23]. However, as we have mentioned above, recent studies have excluded the role of joint incongruence in the development of TMC joint OA[24-37]. Another possible reason for higher incidence in women may be related to the difference in the sizes of the bones. TMC joint composed of smaller bones in women may be exposed to higher levels of stress, because the forces required to generate the same torque for a given task would be higher for a joint with smaller bones[25-27]. Thus, we expect that the TMC joints of females cadavers might show more severe and larger areas of degeneration than male cadavers.

Thirdly, it would be interesting to consider any differences in the wear locations between the left and right hands. There are no reports until now of anatomical studies comparing the areas and locations of degeneration between the left and right hands. However, two epidemiological studies have reported differences in prevalence of TMC OA between the left and right hands. Wilder *et al*. reported a higher prevalence rate of radiographic TMC OA in the non-dominant hand than in the dominant hand[6]. Another study by Haugen *et al*. reported that radiographic TMC joint OA was more common in the left hand than in the right hand[37]. The two reports appear to be consistent,

because it is well known that the right hand is more frequently the dominant hand, although Wilder *et al*. did not mention if the non-dominant hand was the left or the right hand. Although a higher frequency of degeneration in the dominant hand would be expected, considering that the dominant hand is used more often than the non-dominant hand for daily activities, the reason for the higher frequency of degeneration in the non-dominant hand reported by the aforementioned studies remain unclear.

Fourth, differences in the life style may be related to the distinct wear pattern of the articular cartilage observed in Japanese cadavers. The Japanese are well-known to use chopsticks for eating their meals, while in western countries, fork and knife are used. This difference in lifestyle could explain distinct wear pattern of the articular cartilage observed in Japanese. As mentioned above, the study by Schneider *et al*. revealed three distinct peak contact locations in women during lateral key pinching, cylindrical object grasping, and jar lid twistsing[35]. Among the three positions, cylindrical object grasping is considered to be the closest to the grip used for holding chopsticks. During cylindrical object grasping, the majority of men showed peak contact from the radial to the central region, whereas women showed a broader region of contact, namely, radial-volar region, dorsal-radial region, and ulnar-volar region, in descending order of frequency. The expected wear locations of the articular cartilage based on the common peak contact locations during cylindrical object grasping are summarized in Figure 2.

## Summary

We summarize our hypotheses for future studies in Japanese cadavers as following:

1. Japanese cadavers might show less severe degeneration of the TMC joints than Caucasians cadavers.
2. Females cadavers might show more severe and larger area of degeneration than male cadavers.
3. Degeneration might be identified more in the left or non-dominant hand than in the right hand or dominant hand.
4. Common wear locations in female and male cadavers combined might be observed in the volar-radial to central region. Male cadavers might show more central and compact wear locations than female cadavers.

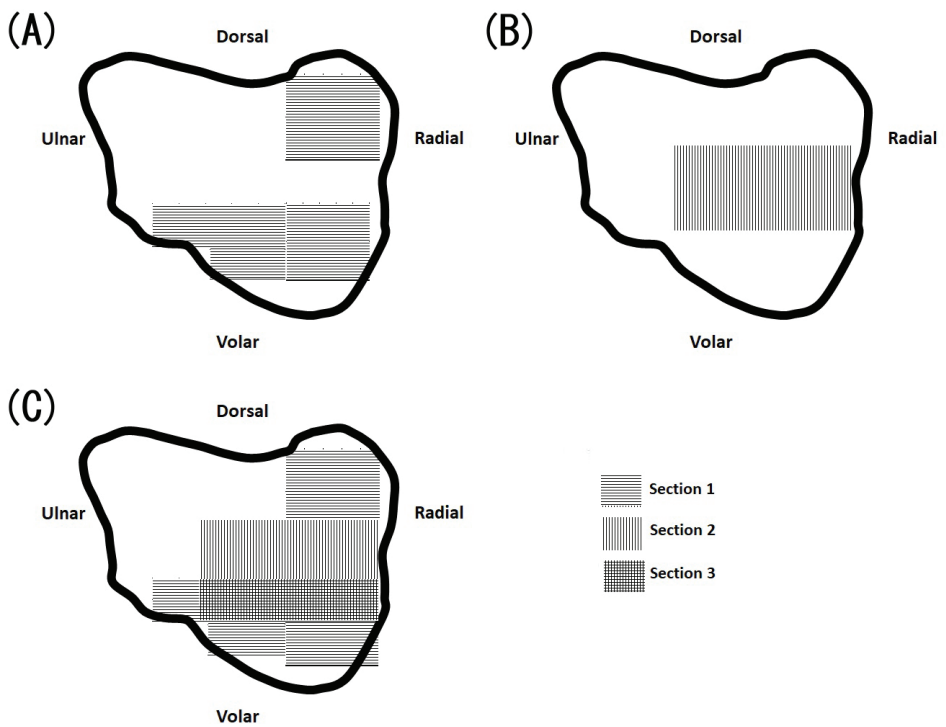


**Figure 2.** Wear locations of the articular cartilage over the articular surface of the right trapezium. (A) Section 1 shows the areas in women. (B) Section 2 shows the area in men. (C) Section 1 and 2 combine. Section 3 shows the common areas overall, including both women and men.

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Corresponding author
Tomonori Sato
E-mail: flutemist@gmail.com