Contact Pressure in the Wrist During Computer Mouse Work

Jong Woo Kang, MD; Dong Ho Kum, MD; Jung Ro Yoon, MD, PhD; Yong Seuk Lee, MD, PhD; Woo Joo Jeon, MD; Jong Woong Park, MD, PhD

Abstract: This study investigated the relationship between computer mouse work and contact pressure around the pisiform. Commonly performed mouse work was simulated using 3 different-shaped mice with 3 forearm positions. When typical mouse work was performed, the contact pressure on the pisiform area was evaluated using a digital pressure sensor and compared with that of the thenar area. Six mouse tasks were simulated. Results indicate that mouse users should avoid wrist-snap dragging and resting their wrist on the edge of the desk to minimize the pressure concentration on the pisiform area.

Since the first commercially available computer mouse emerged in 1981,1,2 mouse use has increased exponentially in the workplace.3-9 Relatedly, the incidence of musculoskeletal disorders related to mouse use appears to have increased steadily among those who use computers for their everyday work.9 Furthermore, the risks of musculoskeletal pathologies associated with the computer devices have become important public health issues worldwide.7,8,10-12 Several studies have suggested possible pathways involved in the development of upper extremity musculoskeletal disorders associated with mouse use. They described the cumulative nature of disorders caused by internal forces acting on body tissue (termed a dose) due to mouse use. This dose causes responses in the body such as an increase in circulation and local muscle fatigue and other physiological and biomechanical responses. If insufficient time is given to allow tissue regeneration, a series of responses may further reduce the available tissue regeneration capacity. Accordingly, cumulative cycles are likely to continue until pain, swelling, or movement limitation occurs.16

More than 50% of the several musculoskeletal symptoms associated with mouse work concern wrist pain.4,11 Nevertheless, the etiologies and causative factors of mouse-associated wrist pain have not been fully investigated.

The current authors have seen many patients who reported ulnar-sided wrist pain, including flexor carpi ulnaris tendinitis (ie, tenosynovitis, calcific tendinitis, and strain), pisotriquetral osteoarthritis, Guyon’s canal syndrome, and hard corns. Interestingly, some of these patients were unable to recall a specific causative event, although they guessed that their everyday office work may have induced their wrist problems. The authors attempted to identify the cause of their ulnar-sided wrist pain and noted that mice cause the hand to supinate on the desk. In this position, the pisiform area prominently contacts the top of the desk (Figure 1). Therefore, the authors hypothesized that excessive contact pressure around the pisiform area might be one of the causative factors of ulnar-sided wrist pain during mouse use.

To verify the hypothesis, the authors evaluated the relationship between mouse use and contact pressure around the pisiform area using a digital pressure sensor. Commonly performed mouse-work tasks were simulated using 3 different-shaped commercially available mice with 3 forearm positions.

Dr Kang is from the Department of Orthopedic Surgery, Inje University, Busan, Drs Kum and Park are from the Department of Orthopedic Surgery, Korea University Ansan Hospital, Ansan, Dr Yoon is from the Department of Orthopedic Surgery, Bohun Joongang Hospital, Seoul, Dr Lee is from the Department of Orthopedic Surgery, Gacheon College of Medicine, Incheon, and Dr Jeon is from Barun Joint Orthopedics, Seongnam, Korea.

Drs Kang, Kum, Yoon, Lee, Jeon, and Park have no relevant financial relationships to disclose.

Correspondence should be addressed to: Jong Woong Park, MD, PhD, Department of Orthopedic Surgery, Korea University Ansan Hospital, 516, Gojum-dong, Danwon-gu, Ansan 425-70, Korea (ospark@korea.ac.kr). doi: 10.3928/01477447-20120919-06

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Materials and Methods

Twenty healthy, right-hand-dominant adults (10 men and 10 women) participated in this study (mean age, 30 years; range, 23-46 years). All participants voluntarily signed informed consent forms that were approved by the authors’ hospital institutional review board. Candidates with a history of previous or present wrist pain, a wrist-related disease, or an anatomical abnormality of the wrist were excluded. Using a digital pressure sensor (Pliance-X; Novel, Munich, Germany), the authors evaluated the differences between contact pressure distributions at the pisiform and thenar areas in the resting position (baseline pressure) and contact pressure changes in the pisiform area vs baseline pressure during various mouse work tasks.

Each participant was asked to perform a set of mouse work tasks with the 3 mice in 3 forearm resting positions on the desk. The mouse work tasks simulated were a left click, a right click, a left double click, a right double click, dragging the mouse by wrist snap, and dragging by whole-hand movement. The single click involved pressing and releasing a mouse button to trigger an action. The double click involved clicking the same mouse button twice in quick succession. The drag involved pressing and holding the left button and then moving the mouse without releasing the button. Dragging by wrist snap involved dragging without sliding the wrist on the desk (ie, moving the mouse while maintaining some wrist contact on the desk). Dragging by whole-hand movement involved normal mouse dragging while simultaneously moving the whole hand and wrist with a mouse.

Three different-shaped mice were used: a conventional desktop mouse (Samsung SMH-210U Mouse; Samsung Electronics, Gumi, Korea), a small laptop mouse (Pinte Laptop Mouse; Pinte Co, Lake Zurich, Illinois), and an ergonomic mouse (Microsoft Natural Wireless Laser Mouse 6000; Microsoft Inc, Redmond, Washington). These mice had different outer shapes, although the functional button layouts were similar. The conventional desktop mouse had a left–right symmetrical design and heights with 2 buttons. The laptop mouse also had a symmetrical design with 2 buttons, and the ergonomic mouse had an unsymmetrical design (left is high and right is low), which caused the hand to adopt a more supinated position from the desk surface than the small laptop mouse or the conventional desktop mouse (Figure 2). The same set of mouse work tasks were performed for different forearm positions on the desk: with the wrist resting on the edge of the desk, with half of the forearm on the desk, and with the whole forearm on the desk (Figure 3).

For all tasks, participants were seated in front of a workstation that consisted of a chair with no armrests and a work surface. The components were
all adjusted for each individual, such that the participants’ thighs were horizontal to the ground and the table surface was at resting elbow height. The contact pressures measured using the pressure sensor underneath the wrist were analyzed using Pliance-x/B software (Novel), which was wirelessly connected to the pressure sensor.

Statistical analyses were performed using SPSS version 12.0 software (SPSS Inc, Chicago, Illinois). A 3-way repeated-measures analysis of variance was used to investigate contact pressure differences for mouse types, forearm positions, and mouse tasks. Interactions between mouse types and forearm positions, between mouse types and mouse tasks, and between forearm positions and mouse tasks were considered. However, interactions between the 3 variables were not considered due to the small sample size. Post-hoc pairwise comparisons were conducted using the multiple t test for all pairs with a Bonferroni adjustment. Statistical significance was accepted when the probability of a false-positive was less than 5%. Statistical significance was accepted for P values less than .05.

RESULTS

An average of 7.6-fold more contact pressure was concentrated on the pisiform area than on the thenar area when participants rested their wrists on the edge of the desk using a conventional desktop mouse. Although most of the participants felt that the ergonomic mouse provided a more comfortable hand-grip position, the contact pressure around the pisiform area was highest with this mouse compared with that of the thenar area (10.6-fold greater; P < .05). The small laptop mouse had the lowest contact pressure around the pisiform area (6.6-fold greater than the thenar area; P < .05) (Figure 4).

Changing the forearm position on the desk significantly affected the contact pressure. For a conventional mouse, the contact pressure around the pisiform area progressively decreased as the portion of the forearm resting on the desk increased: 11.6 kPa with the wrist on the edge of the desk, 6.8 kPa with half of the forearm on the desk, and 5.5 kPa with the whole forearm on the desk (P < .05). For the ergonomic mouse and the small laptop mouse, the trends remained the same: conventional mouse, 13.7, 7.7, and 7.1 kPa, respectively (P < .001); and small laptop mouse, 7.9, 4.9, and 4.3 kPa, respectively (P < .05) (Table; Figure 4).

According to the mouse work tasks, the contact pressure for the button-clicking operations for each mouse was not significantly affected by mouse design or forearm position. However, mouse dragging by wrist snap increased the contact pressure around the pisiform area compared with the resting pressure.

Table

<table>
<thead>
<tr>
<th>Variable</th>
<th>Conventional Desktop</th>
<th>Small Laptop</th>
<th>Ergonomic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forearm position</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wrist on edge of desk</td>
<td>11.6 ± 1.8</td>
<td>7.9 ± .8</td>
<td>13.7 ± 1.9</td>
</tr>
<tr>
<td>Half of forearm on</td>
<td>6.8 ± 1.2</td>
<td>4.9 ± .8</td>
<td>7.7 ± 1.5</td>
</tr>
<tr>
<td>Whole forearm on</td>
<td>5.5 ± .9</td>
<td>4.3 ± .6</td>
<td>7.1 ± .3</td>
</tr>
<tr>
<td>Mouse work tasks</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Resting</td>
<td>11.2 ± 1.2</td>
<td>8.3 ± .8</td>
<td>14.1 ± 1.4</td>
</tr>
<tr>
<td>Left click</td>
<td>10.4 ± 1.2</td>
<td>6.3 ± .6</td>
<td>13.0 ± 1.3</td>
</tr>
<tr>
<td>Right click</td>
<td>9.3 ± 1.1</td>
<td>6.7 ± .6</td>
<td>12.5 ± 1.2</td>
</tr>
<tr>
<td>Left double click</td>
<td>9.4 ± 1.2</td>
<td>6.8 ± .7</td>
<td>11.9 ± 1.1</td>
</tr>
<tr>
<td>Right double click</td>
<td>9.0 ± 1.2</td>
<td>6.8 ± .6</td>
<td>11.7 ± 1.0</td>
</tr>
<tr>
<td>Wrist-snap dragging</td>
<td>17.6 ± 2.0</td>
<td>13.4 ± 1.8</td>
<td>24.1 ± 2.2</td>
</tr>
<tr>
<td>Whole-hand dragging</td>
<td>10.4 ± 1.1</td>
<td>6.8 ± .9</td>
<td>12.5 ± 1.6</td>
</tr>
</tbody>
</table>

*All values are mean kPa ± standard error of the mean.
For an ergonomic mouse with the wrist on the edge of the desk, the contact pressure during wrist-snap dragging reached an average of 24.1 kPa (1.7-fold greater than the resting pressure). The contact pressures during wrist-snap dragging were 17.6 and 13.4 kPa for the conventional and small laptop mice, respectively ($P<.001$) (Table; Figure 4). When the mice were moved with the whole hand, the contact pressure increases around the pisiform area were less than those caused by wrist-snap dragging; however, they showed increased pressure concentrations compared with the resting pressures for each mouse design and forearm position.

**Discussion**

In this study, the authors evaluated the effect of computer mouse use on wrist pressure, which can potentially lead to ulnar-sided wrist pain and ulnar-sided pathologies, such as tendinitis, calcifications, arthritis, and neuropathies. The authors measured contact pressures around the wrist using 3 commonly available mouse designs. The tasks most routinely performed with a mouse were simulated using 3 forearm positions on a desk.

The results of this study showed that the contact pressure was concentrated around the ulnar side of the wrist, particularly around the pisiform, which is the most prominent bone in the hypothenar area. In fact, an average of 7.6-fold more contact pressure was concentrated on the pisiform area than on the thenar area when participants rested their wrists on the edge of the desk using a conventional desktop mouse, and this contact pressure was the highest when the wrist rested on the edge of the desk. According to the mouse design, the ergonomic mouse caused the highest pisiform contact pressures, and the small laptop mouse caused the lowest pressure.

These differences could have been affected by specific mouse design. When gripping the mouse, the hand and wrist are spontaneously supinated from the surface of the desk to fit the index and middle finger tip on the left- and right-click buttons. The volar side of the wrist has 2 prominent bony protrusions on each side: the scaphoid tubercle in the thenar area and the pisiform in the hypothenar area. When the wrist and hand are supinated from the surface of the desk, the pisiform is more likely to contact the desk due to its ulnar-sided location in the wrist. The asymmetrical design of an ergonomic mouse (a declined right side) causes the hand to adopt a more supinated position than a conventional mouse.

Although the user generally feels more comfortable with the ergonomic mouse due to decreased forearm muscle fatigue, this intended supination of the hand and wrist by the ergonomic design paradoxically increased the contact pressure around the pisiform. Although the small laptop mouse generated the least contact pressure around the pisiform, all participants found it less comfortable compared with the others. A relatively small portion of the hand rests on the body of a small laptop mouse, and the supination of the hand was minimal. Consequently, the contact pressure was more evenly distributed on each side of the wrist.

Changing the position of the forearm on the desk was found to affect contact pressure. The pisiform area contact pressure was highest when the wrist rested on the edge of the desk, and this was significantly higher than the other forearm positions ($P<.001$). The contact pressure around the pisiform was lowest when the whole forearm rested on the desk ($P<.05$). These results were unchanged by mouse design or work task. When a greater portion of the forearm rested on the desk, the contact pressure more evenly distributed on the wrist and forearm, and consequently, the focal pressure concentration around the wrist markedly decreased.

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However, when the wrist rested on the edge of the desk, the weight of the whole forearm was added to the contact pressure of the wrist because, in this position, the forearm naturally falls below the surface level of the desk.

This study showed that mouse dragging using only a wrist snap significantly increased contact pressure around the pisiform ($P<.001$). The authors carefully observed routine computer mouse use and found that computer users typically drag their mice in 2 ways. Some move the mouse using a wrist snap without detaching their wrist from the desk, and others move it by simultaneously sliding their wrist and hand over the desk. These 2 habits vary even in the same individual according to their body position in front of a computer monitor.

When a worker writes a document using a mouse and a keyboard, the worker generally sits on the chair with good posture and the forearm rests deeper on the desk. However, during Internet surfing while in a relaxed position, individuals’ backs typically lean on the chair, and an increased chance exists of mouse dragging by wrist snap while resting the wrist on the edge of the desk. During wrist-snap dragging, the pisiform, which is the most prominent bone in the ulnar side of the wrist, acts as a pivot point for the mouse’s movement.

In an investigation of wrist pain in computer workers, Karlqvist et al. reported that mice promoted less neutral postures (higher metacarpophalangeal joint adduction and flexion and higher wrist extension) and higher wrist extensor muscle activity. They concluded that these nonphysiological postures could potentially cause painful wrist disorders if workers were exposed to chronic repeated stress.

Mouse users exhibit finger-lifting behaviors and extended-finger postures depending on the intensity and duration of mouse use. Therefore, prolonged static-lifting behavior and extended-finger postures may place intensive mouse
users at risk of developing musculoskeletal pains of the forearm, wrist, or hand.\textsuperscript{14} Although no data are available in the literature about the ulnar-sided wrist pain associated with mouse use, the current results show the potential for musculoskeletal overuse syndrome around the wrist caused by the overuse or misuse of a mouse.

Anatomically, the pisiform provides a site of attachment for various structures that form a complex suspension unit (the tendon of the flexor carpi ulnaris, flexor retinaculum, and extensor retinaculum; the pisohamate and pisometacarpal ligaments; the abductor digiti minimi muscle; and the meniscal homolog of the triangular fibrocartilage complex), and the transverse carpal ligament is also attached on its ulnar side, delimiting Guyon’s canal.\textsuperscript{18,19} Therefore, chronic repeated exposure to abnormal contact around the pisiform can induce various pathologic conditions at the ulnar side of the wrist (e.g., flexor carpi ulnaris calcific tendinitis, tenosynovitis, pisotriquetral osteoarthritis, Guyon’s canal syndrome, hard corns, and triangular fibrocartilage complex lesion).\textsuperscript{17} Cases of tenosynovitis of the wrist caused by a combination of friction and pressure on the wrist joint tendon due to faulty positioning of the hand and wrist have been reported by Franco et al.\textsuperscript{15} They concluded that, to prevent tenosynovitis of the wrist, it is important to avoid resting the weight of the hand on the ulnar side of the wrist.

The limitations of the current study include the testing of only 3 representative mouse designs and the fact that several simplified mouse tasks (6 motions and 3 forearm positions) were simulated without considering special situations using the mouse. However, despite these limitations, this study reveals the biomechanical risk factors associated with mouse-induced ulnar-sided wrist pain.

**CONCLUSION**

Accumulated stresses caused by overuse of a computer mouse may induce ulnar-sided wrist pain due to pressure concentration around the pisiform area. According to the results of this study, the authors recommend that mouse users should avoid wrist-snap dragging and resting their wrist on the edge of the desk to minimize the risk of ulnar-sided wrist pain. A well-padded mouse pad or wrist pad would also be helpful for relieving the stress concentration on the pisiform area.

**REFERENCES**