Analysis and improvement of surgeons' posture during ophthalmic microsurgery (Part 1): Heads-up surgery with a 3D monitor

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Abstract. Ophthalmic surgeons are easily to get exhausted because their operative postures become complex. Recently, a new surgical system using a 3D monitor has been developed. The system allows surgeons to be freed from viewing through microscope, and the surgeons' fatigue is expected to be reduced. We investigated the surgeon's posture using the 3D monitoring system compared with the conventional microscopic system. Seven surgeons performed microsurgeries. We measured pelvic tilt angles and pressure distributions on a seat. Alignment of human-thing relationships was monitored by photography and radiography. There was a clear difference in the surgeon's posture between the two systems. Improvement of a microscopy and utilization of the back support are recommended for decreasing surgeon's fatigue and increasing stability of upper body.

Keywords: microsurgery, heads-up surgery, three-dimensional monitor

1. Background

1.1 Ophthalmic Surgery with a surgical microscope

Ophthalmic surgeons are easily to get exhausted by the use of surgical microscope because their operative postures become complex. The surgeons have to do a microsurgery with both hands and to operate the foot switch with both feet, while looking a microscope. After the surgery several hours, the surgeons feel fatigue to neck, shoulder, back, waist and feet. (Figure 1)

1.2 Heads-up surgery

Recently, a new surgical system using a three-dimensional (3D) monitor has been developed. In heads-up surgery, the surgeon performs microsurgery by viewing the microscopic image on a large 3D monitor instead of looking through the eyepieces of

a microscope. (Figure 2) The system allows surgeons to be freed from viewing through microscope, and the surgeons' fatigue is expected to be reduced.

We investigated possible advantages and disadvantages of the 3D monitoring system (3DS) compared with the conventional microscopic system (MS) on the surgeons' posture.

Figure 1: *The standard posture of the ophthalmic surgeon during microsurgery.*

Figure 2: *''heads-up surgery'' The surgeon performs microsurgery not by looking through the eyepieces of a microscope but by viewing the 3D monitor set on forward right of the surgeon.*

2. Method

2.1 Object and methods

Seven ophthalmic surgeons performed ''section paper test'' (Figure 3) in an operating room, either with a 3D monitor surgery system (3DS) by ultrahigh-definition 4K 3D monitor system (NGENUITY, Alcon Co.), or a conventional microscopic surgical system (MS). During this test, we measured pelvic tilt angles and pressure distributions on a seat. Alignment of human-thing relationships (medical equipment, chairs, monitoring systems, and surgeons) was monitored by photography and radiography.

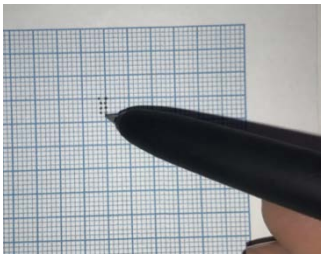

Figure 3: *''Section paper test'' The surgeon plots the points on the 1mmX1mm section paper, using a pen with 0.38mm tip. First 30 seconds, with a conventional microscopic surgical system, next 30 seconds, with a 3D monitor surgery system.*

2.2 The measurement of the pressure distribution and pelvic tilt angle

A pressure sensing device (X-sensor, XSENSOR Co.) was used for measuring the contact area on a surgeon's seat surface. Concurrently, the angle of pelvic tilt was measured. We fitted a gyro sensor (VR-sensor, Datatec Co.) at the surgeon's waist and set the pelvic tilt angle of zero at the standing upright position. (Figure 4)

Figure 4: *set the pelvic tilt angle of zero at the standing upright position*

2.3 Monitor of aliment from upside and left side

We marked several points on a surgeon's body, and took a photograph from over-head of a surgeon by the selfie stick and smartphone, when the surgeon demonstrated a section paper test in MS and 3DS. (Figure 5)
For monitor of the spinal curve, we took X-rays from left side of one surgeon in a X-ray room, during the surgeon demonstrate a microsurgery in both surgery style. (Figure 6)

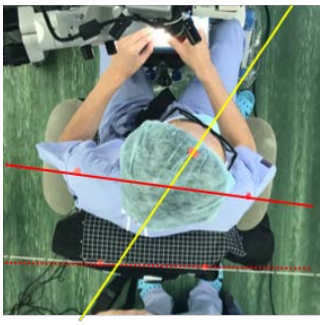

Figure 5: *We marked surgeon's acromia, front and back of head and a seat.*

Figure 6: *We took a X-ray from left side in the X-ray room.*

3. Results and discussions

3.1 The pressure distribution on a seat

The distribution pattern of pressure for a seat pan showed a similar tendency in 3DS with MS. The pressure for ischial tuberosity was recorded over 256mmHg in all surgeons and both system (3DS or MS). In both system, the pressure for a seat back was so low and frequently indicated subthreshold.

3.2 The pelvic tilt angle

Six of 7 surgeons' pelvic angle with 3DS tilted more backward than with MS. The pelvic tilt angle of the Zen sitting position was reported to be -5 degrees, and that of the Seiza position to be -12 degrees. (Table 1)

	surgeon A	surgeon B	surgeon C	surgeon D	surgeon E	surgeon F	surgeon G
MS	-19.5	-7.5	-18.8	-9.7	-6.4	-11.5	-4.3
3DS	-20.6	-12.3	-21.6	-8.3	-12.8	-15.9	-15.0

Table 1: *The pelvic tilt angles. The positive values represent a forward pelvis rotation while negative values signify backward rotation relative to standing.*

3.3 Monitor from upside

The twist of upper body was observed through the photographic analysis in 3DS. All surgeons were needed to rotate right front in 3DS, because the 3D monitor is set on the right forward, naturally a face and a line made by both shoulder rotated right. (Figure 7)

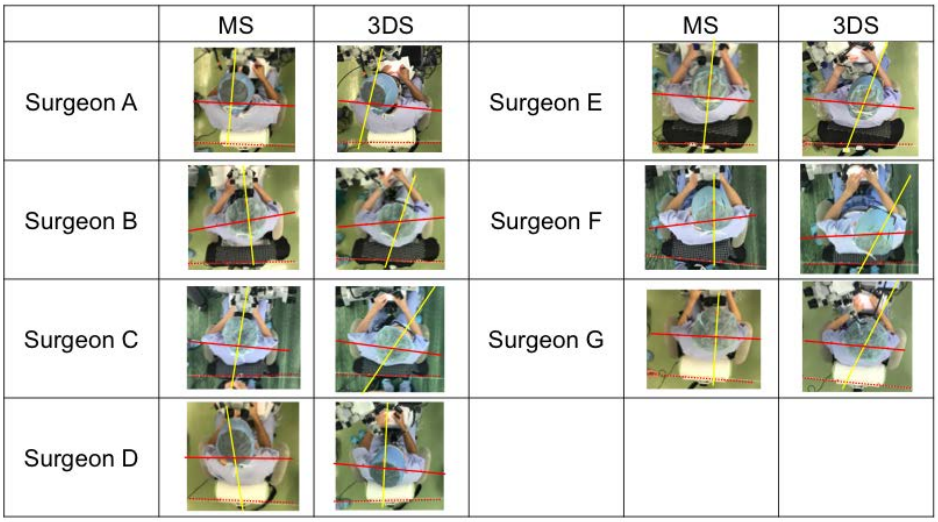

Figure 7: *We took the photograph from upside of the surgeons during section paper test.*

3.4 Monitor from left side by X-rays

When the surgeon performed an operation in MS, the cervical spine of the surgeon became linearized, but lumbar spine followed a physiological curve according to the X-rays image. It is seemingly caused by a restriction of neck motion when looking the eyepieces.

In 3DS, according to the other X-rays image, the surgeon's cervical spine followed a physiological curve, but lumbar spine became out of the physiological curve with a backward pelvic rotation. It is seemingly caused by the increase of the flexibility of surgeon's neck because the surgeon was freed from looking the eyepieces.(Figure 8)

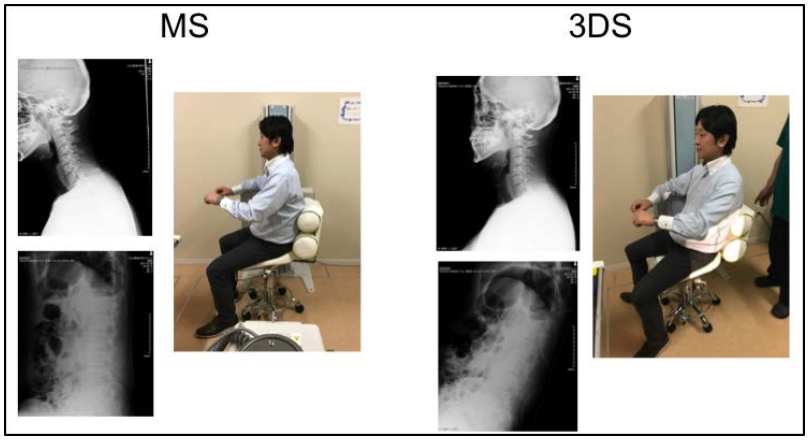

Figure 8: *Monitor from left side by X-ray. The surgeon is demonstrating the both microsurgery Style in the X-ray room.*

4. Discussions

4.1 The comparison of postures in MS with 3DS

We compared the surgeon's posture demonstrating a microsurgery in MD with 3DS. The problem in both style was the high pressure for a seat pan. The decrease

of the pressure for a seat pan and the increase the area touched with a surgeon's hip will decrease the fatigue of a surgeon's hip.

Surgeons' posture in MS was likely to produce less burden to lumbar part than in 3DS, because of the backward of pelvic tilt angle. However, the linearization of cervical spine was indicated in MS, it was presumed that this linearization was occurred by a restriction of motion when looking the eyepieces and made the burden for the surgeon's neck. It is expected to improve the more flexible eyepieces of a microscopy.

When the surgeon performed an operation in 3DS, the surgeon's neck spine was seen to keep physiological curve according to an X-ray image. It is seemingly caused by the increase of the flexibility of surgeon's neck because the surgeon didn't need to look the eyepieces in 3DS. On the other hand, the rotation of upper body was indicated by the photograph from upside of the surgeon. This problem seems to be resolved by setting a monitor on the straight in front of a surgeon. But it is not easy to solve this problem because there is the microscope tube on the front of a surgeon. The development of the smaller microscope tube is expected. The loss of physiological lumbar curve and the backward of the pelvic tilt angle were observed, while the pressure on the back support of the seat was low. It is presumed that the effective use of back support is necessary to reduce the burden of the surgeon's waist.

4.2 The availability of back support

In both system (MS and 3DS), the pressure for the seat back was low. This is caused by the inclined posture of surgeons. It is assumed that the use of the back support can make the upper body more stable and the related risks of surgeon's fatigue can be decreased.

5. Conclusion

There was a clear difference in the surgeons' posture between the two systems. Improvement of a microscopy and utilization of the back support are recommended for decreasing surgeon's fatigue and increasing stability of the upper body. Another report from us on a development of a chair that is intended to reduce the surgeons' burden has been described in the same meeting.

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