Original Article

# Surgeon's Neck Posture during Spine Surgeries: "The Unrecognised Potential Occupational Hazard"

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## Abstract

**Study Design:** Observational study. **Purpose:** The purpose of this study is to analyze the surgeon's neck postures while performing lumbar spinal surgeries. **Overview of Literature:** Lumbar spinal surgeries are on rising trend, and with increase in number of procedures, the average time spent by a spine surgeon performing surgical procedures is also increasing. The effect of operating posture on the surgeon's neck is largely unknown. From the studies conducted on usage of smartphones, abnormal neck postures, especially the forward head posture (FHP), were found to adversely affect the cervical spine of individuals. The present study analyzes the neck position of spine surgeons during lumbar spine surgeries. **Methodology:** Sixty video recordings (25 open transforaminal lumbar interbody fusions [TLIFs] and 35 lumbar decompression [LD] procedures – 15 with headlight and 20 with operating microscope) of surgeries performed by three spine surgeons of different heights were analyzed. Running videos of the surgeries were recorded concentrating on the surgeons with reflective markers taped to their surface landmarks corresponding to C7 spinous process, tragus of the ear, and outer canthus of the eye. Video recordings were standardized by a fixed video recorder in the same operating theater. Snapshots from the video were obtained whenever the surgeon changes the position. Head flexion angle (HFA), neck flexion angle (NFA), and cervical angle (CA) were measured and analyzed. **Results:** During TLIF, HFA and NFA were significantly higher during the phases of decompression and fusion ($P < 0.05$). The average CA of all surgeons was lower, thereby adversely affecting the cervical spine (20.15° ± 5.05°). During LD, CA showed significant difference between usage of microscope and headlight ($P < 0.001$). **Conclusion:** Surgeon's FHP is frequently caused by a compromise between the need to perform surgery with hands, without elevating the arms, and simultaneous control of gaze at surgical field. The usage of microscope was found to reduce the stress on neck while performing surgery.

**Keywords:** *Ergonomics, forward head posture, postural analysis, spine surgeon, surgeon's neck*

## Introduction

Lumbar spine surgeries are on a rising trend in the past few decades, the reasons being many from advancement of instrumentation technologies to experience of the surgeons. As a reason, the average time spent by a spine surgeon performing surgical procedures is also increasing. Since intraoperative position of one's own neck is not regularly assessed or observed by the spine surgeons, the effect of operating posture on the surgeon's neck is largely unknown.

Good posture is defined by the Posture Committee of the American Academy of Orthopedic Surgeons as "the state of muscular and skeletal balance which protects the supporting structures of the body against injury or progressive deformity, irrespective of the position (erect, lying, squatting, or stooping) in which these structures are working or resting".[1] Correct upright posture is defined as when ears are aligned with the shoulders in the same line, leading to least strain on the back when in standing position.[2] To maintain such a good posture, one must be always aware of the position in which he/she is constantly working and correct it on regular basis.

Postural neck pain can be caused by several factors, including sleeping with head elevated too high, overuse of computers or cell phones, and lack of back muscle strength.[3] The common neck-related syndromes are straight neck syndrome and forward head posture (FHP). Loss of natural cervical curve is termed as straight neck syndrome, which is mainly asymptomatic but when neglected can lead

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to pain-associated FHP. According to Hansraj,[4] weight load on the spine dramatically increases when there is an increase in neck flexion ranging from 10 lbs at 0° to 60 lbs at 60°. It is around 10–12 lbs at neutral position and 27, 40, 49, and 60 lbs at 15°, 30°, 45°, and 60°, respectively. According to Szeto *et al*.,[5] when the head is in forward flexion posture for a longer time period, it results in loss of cervical lordosis and potential increase in thoracic kyphosis. FHP combined with increased biodynamic stress of the spine leads to musculoskeletal problems, such as neck pain and headache.[6] There have been reports where temporomandibular dysfunction is also associated with FHP.[7] Several studies have also come up examining the influence of head weight on flexion head posture.[8,9]

Postural analysis has been extensively studied over the last decade, with many development methods gaining importance. The latest reliable developmental methods used advanced technological systems such as computerized photographic systems[10] and X-ray scannograms.[11,12] Methods to evaluate spinal posture have been categorized basically into four groups:

1. Radiography[13] – Reliable and gold standard but involves radiation hazards
2. Three dimensional motion analysis[14] – Reliable but requires costly equipment
3. Video raster stereography analysis[15] – Reliable but did not pass validity studies
4. Photographic posture analysis[16] – Basic objective observational measurement method using anatomical landmarks.

Reliability and clinical use of the photographic analysis have been described in the literature based on its accuracy.[10,17] According to van Niekerk,[18] photographs are reliable indicators of the spine when compared to radiographs using LODOX system.

The purpose of the study is to analyze the effect of FHP on the neck of individuals performing spinal surgeries.

## Methodology

An observational study of 60 videos performed by three spine surgeons (S1, S2, and S3) was conducted at our institute. Heights of the surgeons were calculated using photogrammetry and Photographic Posture Analysis Method by single research analyst. Preoperatively, reflective markers were taped on the side of the surgeons [Figure 1], in the following surface landmarks:

1. C7 spinous process
2. Tragus of the ear
3. Outer canthus of the eye.

Reflective markers used were Styrofoam balls of approximately 20-mm diameter. Running video of the surgery was recorded using NIKON Powershot D3100 placed on a Manfrotto tripod at an angle perpendicular to the operative field concentrating on the performing surgeon primarily. The distance between the field and the camera was set at 2.5 metres. Height of the tripod was adjusted so as to center the head and neck of the surgeon in the field. A precalibrated board was placed in the field of view to allow referencing vertical and horizontal axes from the photograph. Postoperatively, all the videos involving three surgeons were analyzed by single research analyst. The total number of operative videos analyzed was 60 which included 35 lumbar decompression (LD) procedures and 25 transforaminal lumbar interbody fusions (TLIFs). Duration of the whole surgery of TLIF was divided into different phases as exposure, fixation, decompression, fusion, and closure. Videos of LD performed were grouped into Group H – surgery performed with usage of headlight and Group M – surgery performed under microscope. Snapshots of the video were taken whenever the surgeon changes his/her position, and using Surgimap (Spine Software, version 2.2.9.9.4, New York, NY, USA), all images were calibrated. The angles evaluated in the study are described below [Figure 2a-c]:

**Figure 1: Reflective markers taped on side of the surgeon**

1. Head flexion angle (HFA) is the angle between a line connecting C7 to tragus of the ear and tragus to outer canthus[19]
2. Neck flexion angle (NFA) is defined as the angle subtended between vector pointing from C7 to tragus (which corresponds to occipital-cervical joint) and a global vertical line[20]
3. Cervical angle (CA) has been one of the reliable indicators to assess FHP and is defined as the angle formed at the intersection of the horizontal line through the spinous process and tragus of the ear.[21]

## Results

### Analysis of posture during transforaminal lumbar interbody fusions

The average duration of surgery for single-level TLIF is 110.63 min (range 71.77–148.36 min). The average distance between surgeon's center of ear and center of shoulder during the entire surgery is 135.5 mm (range 97.82–190.81 mm) [Table 1].

HFA of all surgeons was observed to be near-normal (S1 – 116.5° ± 6.4°, S2 – 122° ± 5.9°, S3 – 130.6° ± 5.4°) during exposure, abnormally increased (S1 – 145° ± 3.4°, S2 – 143.8° ± 2.9°, S3 – 149.7° ± 4.1°) during decompression, and reduced back to near-normal range (S1 – 120.3° ± 3.0°, S2 – 126.6° ± 2.5°, S3 – 132.3° ± 3.4°) during wound closure.

NFA of the surgeons was also observed to follow a similar trend as of HFA, which showed to be abnormal during decompression (S1 – 76.7 ± 4.2, S2 – 80.2 ± 4.1, and S3 – 98.7 ± 4.5) and fusion (S1 – 68.4 ± 5.3, S2 – 79.7 ± 3.3, S3 – 93.6 ± 4.2).

Decompression and fusion were observed to be the most stressful phases affecting surgeon's neck during TLIF. HFA and NFA were significantly higher during the phases of decompression and fusion when compared with exposure and closure ($P < 0.05$). The average CA of all surgeons was significantly lower in all phases of the entire surgery, thereby adversely affecting the cervical spine (20.15° ± 5.05°).

### Analysis of posture during decompression

HFA and NFA did not alter much in the headlight and microscope groups, while CA showed significant difference ($P < 0.001$). With the usage of microscope, CA was observed to be near-normal for the entire duration [Table 2].

## Discussion

Neck-related syndromes are rapidly increasing as the lifestyle of majority of the population involves looking down using smartphones and longer duration of working hours in front of a computer. FHP being a trending condition affecting the younger generation due to usage of technologies such as smartphones, this can also affect the spine surgeons to a particular level. The number of spine surgeries performed has increased markedly in the past decade due to many innovations in the specialty field.[22,23]

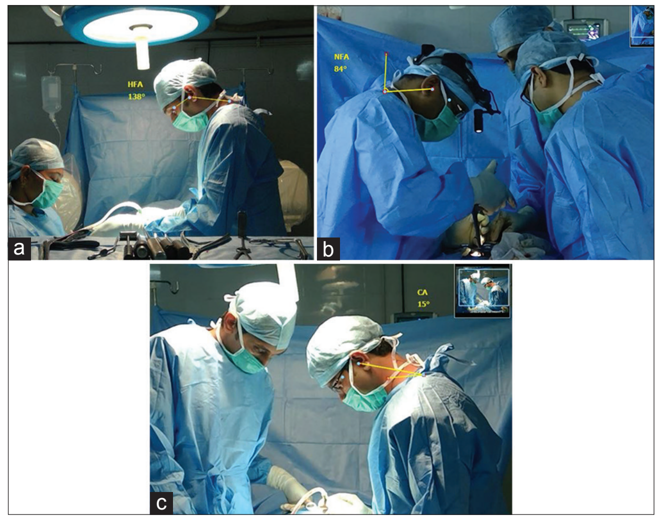


**Figure 2: Snapshot pictures showing head flexion angle (a), neck flexion angle (b), and cervical angle (c) of operating surgeons**

**Table 1: Results showing head flexion angle, neck flexion angle, and cervical angle of operating surgeons during different phases of lumbar fixation and fusion**

| | HFA | | NFA | | CA | | Distance | |
|---|---|---|---|---|---|---|---|---|
| | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** | **Mean** | **SD** |
| Exposure | | | | | | | | |
| Surgeon 1 | 116.5 | 6.4334 | 55 | 4.02768 | 28.6 | 2.319 | 106.93 | 3.459 |
| Surgeon 2 | 122 | 5.9066 | 67 | 3.944 | 20.5 | 1.7795 | 138.08 | 1.5604 |
| Surgeon 3 | 130.6 | 5.4405 | 73 | 4.2018 | 17.3 | 1.6329 | 177.16 | 2.1498 |
| FIXATION | | | | | | | | |
| Surgeon 1 | 131 | 3.8005 | 60.7 | 4.5472 | 25.1 | 3.2472 | 110.22 | 2.8312 |
| Surgeon 2 | 139.8 | 2.7406 | 73.2 | 3.2591 | 19.7 | 2.3118 | 151.03 | 1.8506 |
| Surgeon 3 | 141.3 | 3.4657 | 87.6 | 3.4058 | 14.2 | 2.1421 | 179.05 | 3.2903 |
| Decompression | | | | | | | | |
| Surgeon 1 | 145 | 3.496 | 76.7 | 4.2176 | 21.2 | 2.8596 | 159.67 | 2.8627 |
| Surgeon 2 | 143.8 | 2.9363 | 80.2 | 4.1311 | 18.2 | 2.6583 | 164.17 | 3.2964 |
| Surgeon 3 | 149.7 | 4.139 | 98.7 | 4.5227 | 12.3 | 2.5841 | 190.81 | 2.56476 |
| FUSION | | | | | | | | |
| Surgeon 1 | 135.9 | 3.6651 | 68.4 | 5.3374 | 23.8 | 4.1311 | 136.53 | 2.808 |
| Surgeon 2 | 142.2 | 4.1311 | 79.7 | 3.3349 | 18 | 2.7487 | 157.91 | 2.9898 |
| Surgeon 3 | 150.8 | 4.8716 | 93.6 | 4.2216 | 12.7 | 1.7029 | 187.41 | 2.3278 |
| Closure | | | | | | | | |
| Surgeon 1 | 120.3 | 3.093 | 57.36 | 3.4719 | 28 | 2.9059 | 97.82 | 4.0746 |
| Surgeon 2 | 126.6 | 2.5033 | 67.3 | 2.6687 | 24 | 3.055 | 137.34 | 3.4296 |
| Surgeon 3 | 132.3 | 3.4657 | 77.7 | 3.4334 | 18.7 | 3.3747 | 157.56 | 3.9699 |

**Table 2: Results of lumbar discectomy performed with headlight and microscope**

| | HFA | | NFA | | CA | | Distance | |
|---|---|---|---|---|---|---|---|---|
| | Mean | SD | Mean | SD | Mean | SD | Mean | SD |
| Head light | | | | | | | | |
| Surgeon 1 | 111.4 | 2.6331 | 55.5 | 3.3747 | 22 | 3.1269 | 110.96 | 3.3118 |
| Surgeon 2 | 120.5 | 2.9533 | 58.9 | 4.1486 | 17.1 | 3.6651 | 127.1 | 2.9137 |
| Surgeon 3 | 138 | 2.708 | 73.7 | 3.2676 | 14.4 | 3.2041 | 140.09 | 3.4296 |
| Microscope | | | | | | | | |
| Surgeon 1 | 108.5 | 2.9907 | 57.6 | 3.7771 | 38.1 | 3.0713 | 111.35 | 3.1502 |
| Surgeon 2 | 116.1 | 3.5418 | 59.7 | 3.1287 | 36.4 | 3.1692 | 120.45 | 3.0297 |
| Surgeon 3 | 120.9 | 3.9258 | 65.8 | 2.8982 | 31.1 | 2.8067 | 130.66 | 2.3527 |

If prolonged work is performed with neck in flexion, pain associated with fatigue is the common symptom. Main load on the neck musculature is transferred to surrounding ligaments and capsules of cervical facet joints when head is flexed forward to extreme of its range of motion. Such postures can lead to pain within 15 min, and there is a usual tendency to normalize the posture within 15–60 min due to intense pain. Pressure exerted by head and neck on the disc between the seventh cervical vertebra and the first thoracic vertebra is increased by 3.6 times when the cervical spine is forward flexed maximally.[24]

Dangers of FHP can be described as a "DOMINO EFFECT" since one effect sets of a chain of similar events, leading to a cumulative result, i.e.,

1. Head moves forward, thereby shifting the center of gravity
2. As a primary compensatory mechanism, upper body drifts backward
3. As a secondary compensation to upper body drift, both hips tilt forward.

Hence, FHP can not only cause neck pain but can also be a root cause of mid/lower back pain.

The relation of head to that of the neck can be determined by the following parameters: NFA and CA. According to Yoo,[25] NFA at 38.5° ± 6.02° increases muscle activity of the upper trapezius and splenius capitis muscles, when compared to cervical neutral position. In a series by Lee,[26] muscle fatigue levels of the right and left upper trapezius was highest at 50° and lowest at 30°. In our study, NFA was above 50° in all instances proving that muscle fatigue levels of trapezius is highest during both TLIF and LD.

Many studies stated that normal individuals have mean CA ranging between 40° and 55°.[27,28] In the series by Ruivo *et al*.,[21] cases with FHP associated with neck pain had a CA <50°. Brink *et al*.[29] found smaller CA (<40°) to be the reason behind upper quadrant pain. In the present study, we observed the CA remained <25° for all the surgeons for the entire duration of the surgery, irrespective of the phase. Smaller the CA indicates more the FHP.

According to Kessel,[30] for every inch of FHP, there is an increase in weight of head on the spine by additional 10 pounds. In our study, the average FHP of operating surgeon has been 5.3 inch which amounts to >50 pounds of head weight on the cervical spine. Normally, the weight load of head on spine is 10–12 lbs where the neck flexion is at neutral position and center of the ear lies in the same line that of center of shoulder blades. In the series by Hansraj conducted on bone models, when the neck flexion increases to 60°, load becomes 60 lbs and from here on load could not be calculated since the modules were termed becoming unstable in higher flexion degrees. In the present study, load of head on the spine of surgeons has been consistently above 60 lbs during all the phases of surgery based on the findings of NFA.

Surgeon's FHP is frequently caused by a compromise between the need to perform surgery with hands, without elevating the arms and simultaneous control of gaze at surgical field. The phases showing maximum effect of FHP on the neck of the surgeon are decompression and interbody fusion, whereas exposure and closure of the wound are the least affected phases in the surgery. On an average, if a highly experienced surgeon (>10 years) performs five single-level interbody fusions per week, he/she is expected to be in the position of FHP for about 311.00 hours/year. When the same number of cases if being done by moderately experience surgeon (5 years), they are expected to be in the same abnormal position for about 484.29 hours/year and least experienced (<2 years) time duration would be 642.89 hours/year, which is highly significant when compared to that of the highly experienced spine surgeons. Furthermore, the usage of microscope was found to be beneficial by avoiding the abnormal neck posture angles when compared to the usage of headlight.

Consistent flexion of the spine has been associated with increased cervical compressive loading and reprobate response in the cervical connective tissues.[31,32] The angle of neck flexion in a surgeon that is observed during performing spine surgery is causing a severe load on the surgeon's spine. To avoid excessive consistent pressure on the neck, we suggest changing the posture regularly after each phase for at least 10 s and further recommend spine surgeons to actively perform neck strengthening exercises on a daily basis, which will decrease the effect of FHP on surgeon's neck in the years to come.

## Conclusion

When the neck stays in such an abnormal position on a daily basis, there is a huge pressure on the surgeon's neck making it highly vulnerable for early degeneration. Usage of microscope was found to reduce the stress on neck while performing surgery. The data of this study creates an awareness among spine surgeons about occupational hazards and need for regular neck strengthening exercises.

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### Conflicts of interest

There are no conflicts of interest.

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