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**TITLE PAGE**

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Intermittent feet dorsiflexion as a simple trick to improve cervical fluoroscopic visualization.

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**Abbreviations list**

None

## ABSTRACT

### BACKGROUND

Anterior cervical surgery is routinely performed using fluoroscopy. Particularly in obese, muscular and broad shouldered patients, visualizing the lower cervical levels can be challenging. We recently found that grabbing both feet of the patient at the level of the metatarsals and cranially pushing the feet of the patient, thereby creating dorsiflexion at the ankle joints, seems to increase the number of fluoroscopically visualized cervical levels. We aim to measure the average change in fluoroscopically visualized levels when performing this maneuver.

### METHODS

In 10 consecutive patients undergoing an anterior cervical discectomy and fusion procedure, the number of fluoroscopically visualized cervical levels was counted. Two blinded observers counted the number of visible cervical levels in lateral fluoroscopic cervical images that were taken with and without the execution of the aforementioned maneuver.

### RESULTS

Performing this maneuver added on average almost one vertebral body height to the fluoroscopic image. The additional number of fluoroscopically visible cervical levels was significantly higher in patients younger than 50 years of age, but was not affected by sex or BMI.

### CONCLUSIONS

We propose a simple, convenient and effective technique to increase the number of visualized cervical levels on lateral cervical fluoroscopy, and may have some advantages as compared to other commonly used techniques.

## INTRODUCTION

Anterior cervical surgery is routinely performed using fluoroscopy to determine the surgical level and to control the position of implants preoperatively.<sup>1,2</sup> Although theoretically easy to perform, it can be very hard to obtain a usable lateral fluoroscopic image of the cervical spine due to its anatomical relationship to the shoulders and the upper chest. Particularly in obese, muscular and broad shouldered patients, visualizing the lower cervical levels can be challenging.<sup>1</sup> Insufficient fluoroscopic visualization of the cervical spine is a daily source of frustration and additional radiation exposure,<sup>3,4</sup> and an important factor in wrong level spinal surgery.<sup>5,6</sup> Established techniques to improve cervical fluoroscopic visualization include amongst others oblique rotation of the x-ray tube and caudal traction on the shoulders using tape, weights, manpower or special devices.<sup>1,7-9</sup>

We propose an extremely simple and convenient technique to increase the number of visualized cervical levels. We aim to measure the average change in fluoroscopically visualized levels when performing this maneuver.

## MATERIAL AND METHODS

During anterior cervical discectomy, the patient is positioned supine, with the head in ring cushion and with the neck slightly extended to enlarge the working space. The table is set in minor anti-Trendelenburg position to improve venous drainage from the neck.<sup>1</sup> The arms are put on arm boards immediately next to the body without any traction force applied. No additional support was put under the neck or between the shoulder blades. To check the adequate level pre- as well as intra-operatively we use standard lateral fluoroscopy. In our experience, for most patients visualization of approximately 5 cervical levels is possible without any further modifications.

We recently discovered that asking the circulating nurse or anesthesiologist to stand at the caudal end of the surgery table, firmly grab both feet of the patient at the level of the metatarsals and force the ankles of the patient into dorsiflexion increases the number of fluoroscopically visualized cervical levels. Simple ankle dorsiflexion without moving the heels of the patient cranially is sufficient. To prevent the parallax error, the C-arm was moved so that the cervical level of interest was kept in the same image position. A typical case is shown in figure 1. Supplementary figure 1 displays the fluoroscopic images of all 10 patients with and without the feet dorsiflexion maneuver. Supplementary movie 1 shows an animation of the feet dorsiflexion maneuver with its direct impact on the fluoroscopic image.

In 10 consecutive cases of anterior cervical discectomy and fusion, this technique was used during fluoroscopic determination the level of surgery after positioning and immediately before disinfection and draping. We compared the number of fluoroscopically visible levels with and without feet dorsiflexion by dividing each cervical level into 4 segments (figure 2). The number of fluoroscopically visible levels was scored by a blinded observer in all 20 images that were shown in a random (random.org) order. We used a 2-way paired t-test to compare differences, intra-class correlation coefficient and limits of agreement for inter-rater correlation and ANOVA with post-hoc Bonferroni-corrected 2-way non-paired t-tests to compare subgroups.  $P \leq .05$  was considered statistically significant. With the given effect size and with  $\alpha = .05$  and  $1 - \beta = .80$ , the sample size needed to be at least 5. Calculations were performed with IBM SPSS Statistics 22.0 and IBM SPSS Sample Power 3.0 (Armonk, NY, USA).

## RESULTS

Patient characteristics are shown in table 1. By using our 'feet dorsiflexion technique' the average number of visualized levels increased significantly ( $P < .001$ ) from 5.68 to 6.35 (standard error of mean

0.214 and 0.205, respectively), as shown in figure 2. In all 10 patients there was an increase in the number of fluoroscopically visible cervical levels, ranging from 0.13 to 1.25. The intra-class correlation coefficient between both blinded raters was 0.94, with the limits of agreement being -0.56 and 0.31. Subgroup analysis according to patient factors showed that the additional number of fluoroscopically visible cervical levels was significantly higher in patients younger than 50 years of age, but was not affected by sex or BMI (table 2).

## **DISCUSSION**

In the literature several techniques have been described to overcome the problem of insufficient fluoroscopic visualization of the cervical spine.

One solution to diminish shoulder superimposition is continuous or intermittent upper extremity traction, which is commonly done by using shoulder tape or wrist weight loading or manpower. These techniques are cumbersome, may dislodge catheters, interfere with monitoring devices, disrupt surgical field sterility and expose the person helping to direct radiation.<sup>8</sup> These disadvantages have been at least partly dealt with by various shoulder traction devices recently described.<sup>8,9</sup> However, they still include the risk of brachial plexopathy. In a large neurophysiologically monitored series of anterior cervical spine patients, Schwartz et al. found that 69 of 3806 patients (i.e. 1.8%) showed intra-operative evidence of impending neurological injury secondary to positioning, most commonly noted immediately following shoulder taping and after application of counter-traction. The brachial plexus was the site of evolving injury in 65% of these cases.<sup>10</sup>

A second solution is a 30 degree from horizontal rotation of the X-ray tube, 'throwing the shoulders out of the line of fire', as described first by Choy.<sup>7,11</sup> However, these non-conventional images may be difficult to interpret if not regularly used, increasing the risk of wrong level surgery. Furthermore,



checking for a correct implant position by visualizing the posterior border of the vertebral bodies is impossible using this technique.

Rosahl et al. describe a technique using adhesive radiographic skin markers that are placed before magnetic resonance imaging, but this may produce errors due to skin position shifting between imaging and surgery.<sup>11,12</sup>

Another option is to more extensively open the surgical field up to a fluoroscopically visible level and then count from there. This subjects patients to an increased risk of surgical morbidity including pain and incisional complications.<sup>11</sup>

Other described techniques for cervical level determination, including injection of methylene blue dye at the intended spinous process<sup>13</sup> and elevating one arm to obtain a 'swimmer's view'<sup>14</sup> can hardly be used in anterior spinal surgery. Leonard et al. report on a technique calculating to determine the optimal skin incision site by calculating ratios on pre-operative images alone. However, they acknowledge that they still do use intra-operative fluoroscopy to ensure the correct level as a safety measure.<sup>15</sup>

Simple and transient cranially pushing the metatarsals resulting in dorsiflexion of the patient's feet, however, brings no additional risks, can be easily executed by the circulating nurse or the anesthesiologist, does not interfere with the sterility of the surgical field and produces classical lateral images on which the vertebral level can be easily counted. Comparing our 'feet dorsiflexion technique' to the multiple described techniques of shoulder traction is hard. One might think about comparing the applied force relative to the added number of visualized levels between different methods, but from an anatomical and a practical point of view, physical forces applied to the hands, wrists or shoulders cannot readily be compared to forces applied to the feet.

When comparing 10 consecutive patients in the classic supine position with and without the maneuver by two blinded observers, we found that with this maneuver on average 0.67 additional cervical levels can be fluoroscopically visualized. In our level grading system this equals slightly less than the height of one vertebral body, being also clinically significant. At first sight this may seem a relatively small gain, but since it is mostly made at the C6 level, with C5-6 and C6-7 being the levels most frequently treated with anterior cervical discectomy,<sup>16,17</sup> it can be of utmost importance.

In selected patients where our technique does not provide enough additional fluoroscopic visualized levels, we tend to combine manual shoulder traction and feet dorsiflexion, to diminish the amount of shoulder traction needed. We also found out that even more gain in fluoroscopic visibility can be obtained by setting the surgical table with the leg part tilted upwards, though this can interfere with the global practical setup.

We suppose that the underlying mechanism of this technique is that the feet dorsiflexion shifts the bony structures cranially by levering the ankle joints along the heels, while the friction between the patient and the table keeps the soft structures like the shoulder fat and muscles more or less in place, widening the angle between the shoulders and the neck. Moreover, due to friction between the head and the head rest, the cervical lordosis is amplified, which might also contribute to the improved visualization (figure 1). We speculate that the loss of tissue strain that comes with increasing age might explain why this maneuver is more efficient in patients younger than 50 years old.

## **CONCLUSIONS**

In summary, this simple trick adds almost one vertebral body height to the fluoroscopic visualization of the cervical spine during anterior cervical surgery. It may offer some advantages as compared to other commonly used techniques, as this maneuver does not carry the risk for brachial plexus injury, dislodgment of the catheters, high radiation exposure to the hands of the operating staff or decontamination of the surgical field. The additional number of fluoroscopically visible cervical levels provided by this maneuver may be higher in patients younger than 50 years of age, but seems to be independent of sex and BMI.

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**FIGURE LEGENDS****Figure 1: Typical case**

(A) A patient is positioned supine, with the legs neutrally extended. (B) The feet dorsiflexion maneuver is performed by grabbing both patient's feet firmly at the level of the metatarsals and pushing them cranially. (C) The patient is positioned with the neck slightly extended. (D) While the feet dorsiflexion maneuver is performed, the neck and the head are moved cranially, while the shoulders are relatively stable, opening the angle between the neck and the shoulders and slightly amplifying the lordosis of the neck. (E) Without the feet dorsiflexion maneuver, approximately 5 cervical levels are visualized on lateral fluoroscopy. (F) With the feet dorsiflexion maneuver, in this case more than one extra level is fluoroscopically visualized.

**Figure 2: Number of fluoroscopically visible cervical levels without and with the feet dorsiflexion maneuver**

The number of fluoroscopically visible cervical levels in each single patient and the overall mean are represented with black lines and the bold red line, respectively. This number increases from 6.35 without the feet dorsiflexion maneuver (left side) to 6.35 with the feet dorsiflexion maneuver (right side). Both situations are illustrated with the drawings on the corresponding sides.



## **SUPPLEMENTARY FILES**

### **Supplementary Figure 1:**

The fluoroscopic images of all 10 patients included in the study (1-10) are shown, either without (A) or with (B) feet dorsiflexion maneuver.

### **Supplementary Video 1:**

For demonstration, the first author of the paper is filmed from above (upper left) and aside (lower left), while the feet dorsiflexion maneuver is performed (upper right), resulting in fluoroscopic visualization of additional cervical levels (lower right).