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# Positional alterations of the Kambin's triangle and foraminal areas in the lumbosacral region

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**Objective:** The aim of this anatomical study was to compare the effects of the prone and lateral decubitus positions in endoscopic disc surgery on the Kambin's triangle (KT) and neural foramina zones in the lumbosacral region.

**Methods:** The study included 32 healthy volunteers (16 females and 16 males). Bilateral KT areas (KTA) and neural foraminal areas (FA) of the L4-L5 and L5-S1 levels in the prone and lateral decubitus positions were calculated depending on the freehand region of interest measurements on magnetic resonance images. KTA and FA values for each side and level in the prone and lateral decubitus positions were compared.

**Results:** Mean left KTA value in the prone and right lateral decubitus positions was 0.58 $cm^2$ and 0.69 $cm^2$, respectively, for L4-L5; and 0.69 $cm^2$ and 0.78 $cm^2$, respectively, for L5-S1 levels. Mean right KTA values in the prone and left lateral decubitus positions were 0.54 $cm^2$ and 0.65 $cm^2$ for L4-L5; and 0.69 $cm^2$ and 0.81 $cm^2$ for L5-S1, respectively. The differences in the KTA between prone and lateral decubitus positions for both levels and both sides were statistically significant (p=0.05). Only the difference in the FA between the prone and lateral decubitus positions at L5-S1 level on the right side was statistically significant (p=0.05).

**Conclusion:** The KTA is wider in the lateral decubitus position than in the prone position at the levels of L4-L5 and L5-S1.

**Key words:** Endoscopic disc surgery; foraminal area; Kambin's triangle; lateral decubitus; prone.

Endoscopic lumbar disc surgery is becoming more popular in parallel with evolving technology. Minimally invasive surgery for lumbar disc herniation aims to provide surgical options that optimally address the disc pathology without producing the iatrogenic morbidities associated with open surgical procedures.[1] Kambin's triangle (KT) was defined by Parviz Kambin, and must be identified in order to obtain safe access to the disc for successful endoscopic technique.[2-4] Safe access prevents iatrogenic nerve damage.[4] It has been reported that complications such as nerve root problems occur with decreasing frequency as the surgical experience increases.[5]

Many surgeons prefer the prone position although some surgeons prefer the lateral decubitus position.[4-8] The lateral decubitus position has been reported to allow larger working space,[6,9] although the effect of the

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lateral decubitus or prone position on the KT or neural foramina has not been reported.

The purpose of this study was to identify the effect of the prone and lateral decubitus positions on the cross-sectional dimensions of the KT and neural foramina as measured on magnetic resonance images.

## Patients and Methods

The study included 32 healthy volunteers (16 females and 16 males) between May 2012 and June 2012. None of the volunteers had any clinical or radiological documented orthopedic or spinal problems. The study was supported by the Institutional Scientific Research Projects Coordination Unit and local ethics committee approval was obtained in compliance with the latest revision of the Declaration of Helsinki. Written consent was obtained from all participants.

Magnetic resonance imaging examination was done

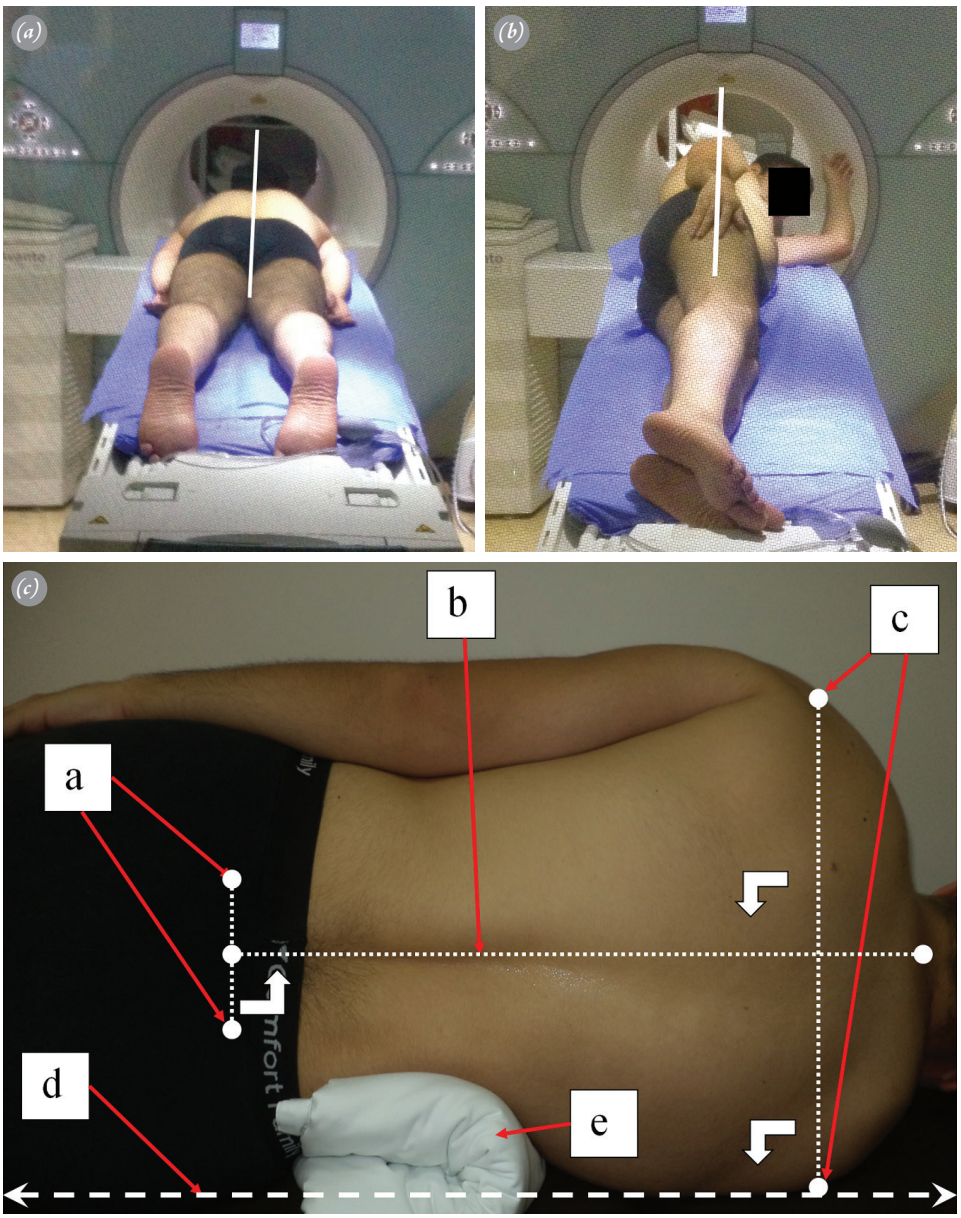


**Fig. 1.** Volunteer positioning within the MRI scanner. **(a)** Prone and **(b)** lateral decubitus positions on the MRI table and straight white line showing parallel orientation to the MRI scanner. **(c)** Schematic view of the lateral decubitus position on the examination table (a: Right and left posterior superior iliac spine (PSIS), b: Midline dorsal sulcus, c: Right and left posterior acromial corner, d: Arbitrary line parallel to the examination table, and e: A flank roll.). [Color figures can be viewed in the online issue, which is available at www.aott.org.tr]

using a 1.5 Tesla (gradient power: 45 milliTesla; software version B17) magnetic resonance imaging system (MAGNETOM Avanto; Siemens AG, Munich, Germany). All MRI examinations were performed by the same technician experienced in musculoskeletal MRI for more than 15 years. An experienced orthopedic surgeon assisted the positioning of healthy volunteers for MRI examinations. Standardized prone and lateral decubitus positions were used for all subjects. For prone positioning, the volunteer was placed in a prone position on the MR table with both arms parallel to the body on each side. The midline dorsal sulcus of the back was in a straight position perpendicular to the arbitrary line caudally drawn between the posterior superior iliac spine and the line cranially drawn to the posterior acromial corners. In the lateral decubitus position, the volunteer was positioned on one side with one arm extended below the head and the other parallel to the body. A flank roll was used to prevent sagging of the lumbar spine. Attention was paid to maintain the midline dorsal sulcus of the back in a straight position parallel to the examination table. An optimal lateral decubitus position was accepted when a line drawn between the trochanter major and the middle of the lateral corner of the acromion was parallel to the MR scanner. All volunteers were examined in the prone and the right and left lateral decubitus positions (Fig. 1).

A T2-weighted 3-dimensional turbo spin-echo with variable flip angle (named SPACE) sequence was used. The imaging parameters were as follows: TR=1000 milliseconds, TE=128 milliseconds, field of view (FOV)=220 mm, matrix=320x320, flip angle=150°, and a single 3-dimensional slab containing 104 submillimetric (0.7 mm) contiguous slices.

The more frequently involved levels of L4-5 and L5-S1 levels were evaluated. The KT area (KTA) and neural foramen area (FA) were measured using imaging software (LEONARDO Workstation; Siemens AG, Munich, Germany) in the satellite workstation. Three-dimensional MR sequences were evaluated by a single radiologist with more than 10 years of experience. The physician

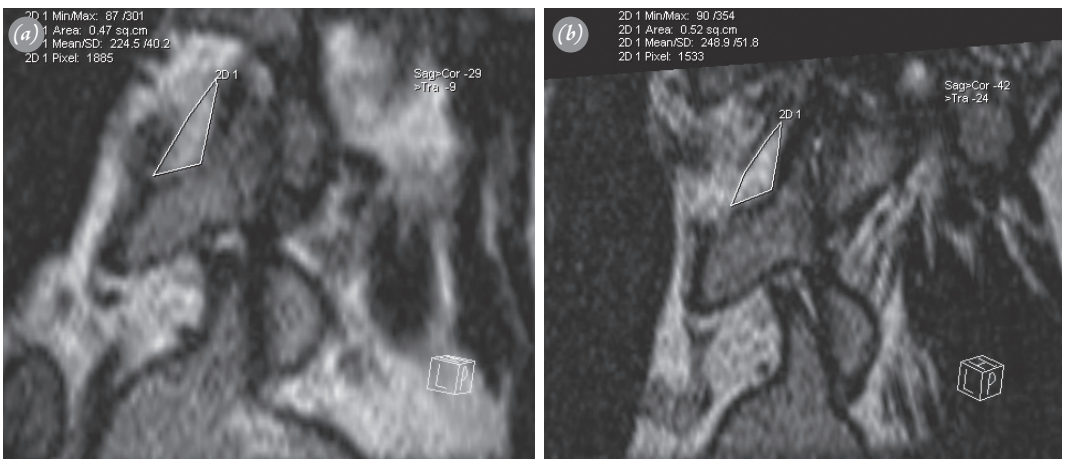


**Fig. 2.** Kambin's triangle area measurement on MRI in **(a)** prone and **(b)** lateral decubitus positions of the same subject.

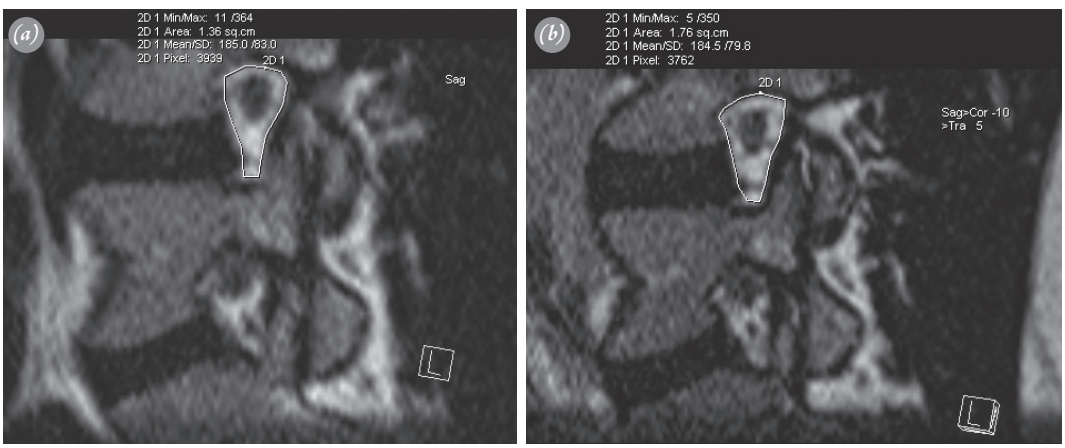


**Fig. 3.** Foraminal area measurement on MRI in **(a)** prone and **(b)** lateral decubitus positions of the same subject.

who made the measurement on the 3-dimensional MR sequence was blinded to the position of the volunteer.

The area for region of interest (ROI) was calculated using the freehand ROI technique. Freehand ROI for quantitative analysis provides maximum, minimum, standard deviation (SD) and mean values in square centimeters (cm2). Measurements were repeated three times and their averages calculated. The measurements were performed by a single radiologist. Representative example for the KTA and FA measurements are shown in Figs. 2 and 3, respectively.

The endoscopic view of the KT was simulated on a 3D-MRI. The true sagittal plane on MRI was accepted as the line that unites the spinous process and the midpoint of the vertebral body. A line was drawn that intersects the true sagittal plane by +25 degrees for the right side and -25 degrees for the left side. Then the true sagittal plane axis was brought parallel to this line to show the neural foramen with an angulation of 25 degrees with respect to the frontal plane.[10] The long axis of the nerve root was accepted as the hypotenuse of the KT, where the frontal surface of the superior articular process of the more caudal vertebra and the upper border of the pedicle of the caudal vertebra were the catheti of the triangle. The bright fat and signal void (black) cortex interface was used to draw the catheti. The area of this triangle, named the KT, was measured by freehand ROI technique.[11,12]

The neural FA was measured from the true sagittal axis plane described above. The image that best displayed the teardrop shape with the largest neural FA at this site was used for the area measurements. The cross-section in which the neural foramen had a teardrop shape and the nerve was seen round at the midpedicular location was used for this purpose.

**Table 1.** Age and BMIs of the volunteers.

| | Age (yrs) (Mean±SD) | BMI (kg/m²) (Mean±SD) |
|---|---|---|
| Male | 28.2±2.2 | 25.9±2.8 |
| Female | 33.9±7.7 | 26.4±6.0 |
| Male+Female | 31.1±6.3 | 26.1±4.6 |

BMI: Body mass index; SD: Standard deviation.

Statistical analyses were performed using SPSS v.19.0 (SPSS Inc., Chicago, IL, USA) software. The Kolmogorov-Smirnov test showed normal distribution for the numeric variables and comparisons were performed by parametric tests. For quantitative data samples, the paired t-test was used. Statistical significance was set to a p value less than 0.05.

## Results

Age and body mass index (BMI) of the study participants are summarized in Table 1. There was no statistically significant difference in BMI values between female and male participants (p=0.738).

Mean KTA and FA values are given in Tables 2 and 3. The mean KTA of the L4-5 and L5-S1 levels were wider in both the right and left lateral decubitus positions than in the prone position in both males and females (Figs. 4 and 5). The KTA differences at these

**Table 2.** Positional comparison of right and left FA and KTA values (mean±SD) measured on both spinal levels in all participants.

| Left side | Spinal level | Prone position | Right LD position | p |
|---|---|---|---|---|
| KTA (cm²) | | | | |
| | L4-L5 | 0.58±0.17 | 0.69±0.20 | **0.001** |
| | L5-S1 | 0.69±0.26 | 0.78±0.30 | **0.025** |
| FA (cm²) | | | | |
| | L4-L5 | 1.49±0.22 | 1.54±0.22 | 0.241 |
| | L5-S1 | 1.52±0.30 | 1.62±0.28 | 0.052 |
| **Right side** | **Spinal level** | **Prone position** | **Left LD position** | **p** |
| KTA (cm²) | | | | |
| | L4-L5 | 0.54±0.18 | 0.65±0.19 | **0.001** |
| | L5-S1 | 0.69±0.25 | 0.81±0.30 | **0.001** |
| FA (cm²) | | | | |
| | L4-L5 | 1.55±0.23 | 1.64±0.27 | 0.056 |
| | L5-S1 | 1.56±0.30 | 1.69±0.27 | **0.020** |

FA: Foraminal area; KTA: Kambin's triangle area; LD: Lateral decubitus; SD: Standard deviation. Significant p values are written in bold.

**Table 3.** Positional comparison of right and left FA and KTA values (mean±SD) measured on both spinal levels in male and female participants.

| | | Female | | | Male | | |
|---|---|---|---|---|---|---|---|
| **Left side** | **Spinal level** | **Prone position** | **Right LD position** | **p** | **Prone position** | **Right LD position** | **p** |
| KTA ($cm^2$) | | | | | | | |
| | L4-L5 | 0.60±0.16 | 0.72±0.20 | **0.002** | 0.57±0.19 | 0.66±0.19 | **0.008** |
| | L5-S1 | 0.70±0.24 | 0.77±0.25 | 0.229 | 0.68±0.29 | 0.78±0.36 | 0.057 |
| FA ($cm^2$) | | | | | | | |
| | L4-L5 | 1.49±0.18 | 1.51±0.20 | 0.671 | 1.50±0.26 | 1.58±0.25 | **0.025** |
| | L5-S1 | 1.49±0.35 | 1.56±0.28 | 0.439 | 1.55±0.25 | 1.68±0.28 | **0.024** |
| **Right side** | **Spinal level** | **Prone position** | **Left LD position** | **p** | **Prone position** | **Left LD position** | **p** |
| KTA ($cm^2$) | | | | | | | |
| | L4-L5 | 0.57±0.15 | 0.65±0.18 | **0.004** | 0.51±0.20 | 0.64±0.20 | **0.002** |
| | L5-S1 | 0.72±0.17 | 0.88±0.28 | **0.002** | 0.66±0.31 | 0.73±0.32 | 0.136 |
| FA ($cm^2$) | | | | | | | |
| | L4-L5 | 1.56±0.25 | 1.61±0.32 | 0.436 | 1.54±0.21 | 1..67±0.22 | 0.067 |
| | L5-S1 | 1.54±0.30 | 1.60±0.23 | 0.311 | 1.58±0.30 | 1.78±0.29 | **0.036** |

FA: Foraminal area; KTA: Kambin's triangle area; LD: Lateral decubitus; SD: Standard deviation. Significant p values are written in bold.

levels between the prone and lateral decubitus positions were statistically significant for the whole study group ($p<0.05$) (Tables 2 and 3).

Although FA values in the lateral decubitus positions were greater than the values in the prone position, the difference between the prone and lateral decubitus positions for the L5-S1 level on the right side only was statistically significant ($p=0.036$).

## Discussion

Percutaneous endoscopic lumbar disc surgery was defined by Kambin and Hijikata.[1,3,13] Transient dysesthesia is the most common complication.[14] Other complications include exiting root irritation and vasovagal syncope or shock due to pain during the insertion of the cannula.[15,16] Complication rates decrease with greater surgeon experience.[5] Transient dysesthesia usually occurs due to cannula insertion or portal placement and can be prevented by confirming the working zone using fluoroscopy.[1,15,17] The KTA must be properly identified to be successful with the technique. Cadaver studies have shown that KTA can be used as a safe entry for intervertebral foraminal procedures.[18] Changes can occur in the lumbar FA and vertebrae alignment due to the position of the body.[19,20] Some surgeons prefer the prone position,[5] while others prefer the lateral decubitus posi-

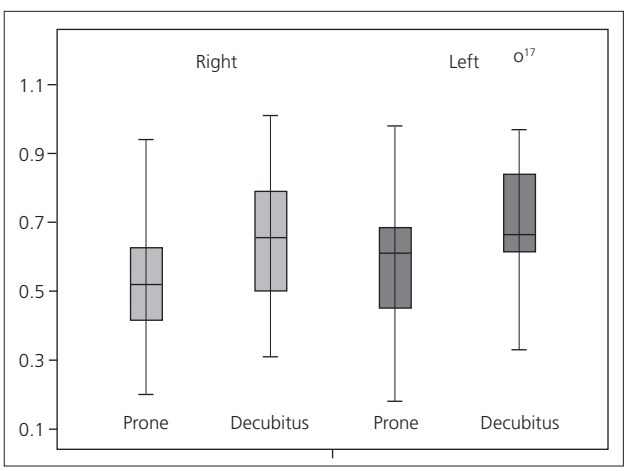


**Fig. 4.** Comparison of mean KTA values in prone and lateral decubitus positions for the L4-5 level. The light gray box indicates the right side L4-5 level, and dark gray box indicates the left side L4-5 level.

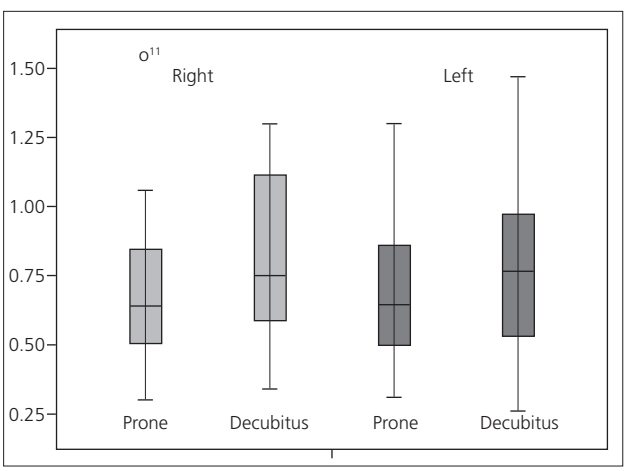


**Fig. 5.** Comparison of mean KTA values in prone and lateral decubitus positions for the L5-S1 level. The light gray box indicates the right side L5-S1 level, and the dark gray box indicates the left side L5-S1 level.

tion for endoscopic spine procedure.[4,6-8,21] In the current study, the FA of both the L4-L5 and L5-S1 levels were wider in the right and left lateral decubitus than in the prone position in all volunteers, although these differences were not statistically significant. This might support the lateral decubitus position preference for patients undergoing transforaminal disc procedures.

The L4-L5 and L5-S1 FAs of the female volunteers were not significantly affected by the position change, although the KTA was greater in the L4-L5 level in the lateral decubitus position than in the prone position. Our study showed that the KTA is wider in the lateral decubitus position than the prone position at the level of L4-L5 and L5-S1. Dural shift to the opposite side due to gravity may be the cause of this situation in the lateral decubitus position.[6,9] Advantages of the lateral decubitus position other than providing more working space include lower blood loss, decreases in intra-abdominal pressure and the possibility of performing a straight leg raising test under local anesthesia.[6,9] Root complication rates, which may be as high as 13% in the prone position, are between 1.14 and 4.76% in the lateral decubitus position.[8,21,22] In addition to the neural structures, the radiculomedullary arteries reach the superior edge of the adjacent nerve root, located just outside or within the neural foramen. It has been shown that the KT approach provides an efficacious and safe transforaminal epidural steroid injection due to fewer neural and vascular complications.[23,24] The mean area change of approximately 0.11 $cm^2$ might reflect a true change in the lateral decubitus position or might simply reflect a measurement error. Nevertheless, these findings as supported by the above mentioned facts probably indicate that the lateral decubitus position provides a wider working area.

The learning curve of endoscopic surgery is long and both education and experience are crucial to its success.[15,25,26] Perioperative complication rates are higher at the start of surgery and exposure from the safe zone can prevent visceral and neurovascular injuries.[15,18] Our results might indicate that the lateral decubitus position may be preferred over the prone position, especially for surgeons who are inexperienced in endoscopic lumbar disc surgery.

We limited our study to healthy volunteers at the L4-L5 and L5-S1 levels as most disc surgeries are performed in these levels.[15,17,22,25,27] Additional studies in groups of patients with lumbosacral problems, larger samples and intra- or interobserver evaluations are necessary.

In conclusion, although mean KTA and FA measurements were quantitatively higher in the lateral decubitus position, only the KTA measurements were significantly different between prone and lateral decubitus positions. The results of this study suggest that the lateral decubitus position might be safer than the prone position in endoscopic disc surgery from the perspective of the area of the critical working zones like the KTA. However, other factors such as orientation problems or surgeon's habits may have an effect on the safety of these surgical procedures.

**Conflics of Interest:** No conflicts declared.

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