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TRANSILIAC ENDOSCOPIC ASSISTED ILIF: A CADAVERIC STUDY

ILIF ASSISTIDA POR ENDOSCOPIA POR VIA TRANSILÍACA: ESTUDO EM CADÁVER

ILIF ASISTIDA POR ENDOSCOPIA TRANSILÍACA: ESTUDIO EN CADÁVER

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ABSTRACT

Objective: Demonstrate the feasibility of endoscopic assisted L5S1 intraforaminal lumbar interbody fusion (iLIF) through a transiliac approach. Methods: Ten transiliac iLIF and ten supra iliac iLIF were performed bilaterally at L5S1 in five randomly selected fresh-frozen human cadavers. The following measurements were recorded: distances from the transiliac track to the iliac crest, posterior superior iliac spine, and superior gluteal neurovascular bundle; pelvic parameters; approach angles; cage's lateral and AP center point ratio (CPR); percentage of the cage crossing the midline in the AP and lateral views. Endplate integrity was assessed through endoscopic visualization. In addition, the facet joint, sacroiliac joint, iliolumbar ligament, and exiting and traversing nerve roots were checked for integrity through anatomic dissection. Results: In the transiliac technique, the axial and coronal approach angles were significantly decreased by 13.5º (95% CI -15.5; -11.5; p value<0.001) and 13.2º (95% CI -15.3; -11.1; p value<0.001), respectively, the sagittal approach angle was significantly increased by 5.4º (95% CI 1.8,8.9; p-value = 0.008), and the AP CPR was significantly higher (MD 0.16; 95% CI 0.12,0.20; p value<0.001). The percentage of the cage crossing the AP view's midline was increased by 31.6% (95% CI 19.8,43.4; p value<0.001). The integrity of endplates, facet joints, sacroiliac joints, iliolumbar ligament, and exiting and traversing nerve roots was maintained. Conclusion: L5S1 transiliac iLIF is a feasible surgical technique. It allows a more centrally placed interbody cage in the coronal plane without compromising the anterior position in the lateral plane. The integrity of the major anatomic structures at risk was preserved. ***Evidence Level III: A case-control study.***

Keywords: Spinal Fusion; Endoscopy; Iliac Crest; Cadaver.

RESUMO

Objetivo: Demonstrar a viabilidade da fusão intersomática lombar assistida por endoscopia (iLIF) em L5S1 através de abordagem transilíaca. Métodos: Dez iLIF por via transilíaca e dez iLIF por via suprailíaca foram realizados bilateralmente em L5S1 em cinco cadáveres selecionados aleatoriamente. Foram registadas as seguintes medidas: Distâncias da via transilíaca até a crista ilíaca, crista ilíaca póstero--superior e feixe neurovascular do glúteo superior; parâmetros pélvicos; ângulos da abordagem; relação do ponto central lateral e AP do cage (CPR); percentagem do cage cruzando a linha média nas incidências AP e perfil. A integridade das placas vertebrais foi avaliada através de visualização endoscópica. Foi verificada através de dissecção anatómica a integridade das articulações facetárias, sacroilíacas, ligamento iliolombar e raízes de L5 e S1. Resultados: Na técnica transilíaca, os ângulos de abordagem axial e coronal foram significativamente menores em 13,5º (CI 95% -15,5;-11,5; p<0,001) e 13,2º (CI 95% -15,3;-11,1; p<0,001), respectivamente, o ângulo de abordagem sagital aumentou significativamente em 5,4º (CI 95% 1,8,8,9; p = 0,008), e o AP CPR foi significativamente maior (MD 0,16; CI 95% 0,12,0,20; p <0,001). A percentagem do cage cruzando a linha média em AP foi superior em 31,6% (CI 95% 19,8,43,4; valor p<0,001). A integridade das placas vertebrais, articulações facetadas, articulações sacroilíacas, ligamento iliolombar e raízes de L5 e S1 foi mantida. Conclusão: A realização de iLIF L5S1 por via transilíaca é uma técnica cirúrgica viável. Permite que o cage seja colocado mais centrado no plano coronal sem comprometer a posição anterior no plano sagital. A integridade das principais estruturas anatómicas em risco foi preservada. ***Nível de Evidencia III: Estudo caso-controle.***

Descriptores*: Fusão vertebral; Endoscopia; Crista Ilíaca; Cadáver.*

RESUMEN

Objetivo: Demostrar la viabilidad de la fusión intersomática lumbar asistida por endoscopia (iLIF) en L5S1 con un abordaje transilíaco. Métodos: Se registraron las siguientes mediciones: distancias del abordaje transilíaco a la cresta ilíaca, la cresta ilíaca posterosuperior y el haz neurovascular glúteo superior; parámetros pélvicos; ángulos de abordaje; relación del punto medio lateral y AP del cage (CPR); porcentaje del cage que cruza la línea media en las incidencias AP y perfil. Se evaluó la integridad de las placas vertebrales por visualización endoscópica. Se comprobó la integridad de las articulaciones facetarias, las articulaciones sacroilíacas, el ligamento iliolumbar y las raíces de L5 y S1 mediante disección anatómica. Resultados: En la técnica transilíaca, los ángulos de abordaje axial y coronal fueron significativamente menores en 13,5° (IC 95% -15,5;-11,5; p<0,001) y 13,2º (IC 95% -15,3;-11,1); p<0,001), respectivamente, el ángulo de aproximación sagital aumentó significativamente en 5,4º (IC 95% 1,8,8,9; p = 0,008), y el AP CPR fue significativamente mayor (MD 0,16; IC 95% 0,12,0,20; p <0,001). El porcentaje del cage que cruzaba la línea media en AP era mayor en un 31,6% (IC 95% 19,8,43,4; valor p <0,001). Se mantuvo la integridad de las placas vertebrales, las articulaciones facetarias, las articulaciones sacroilíacas, el ligamento iliolumbar y las raíces de

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L5 y S1. Conclusión: La iLIF transilíaca L5S1 es una técnica quirúrgica viable. Permite colocar el cage más centrado en el plano coronal sin comprometer la posición anterior en el plano sagital. Se preservó la integridad de las principales estructuras anatómicas en riesgo. ***Nivel de evidencia III: Estudio de casos y controles.***

Descriptores*: Fusión vertebral; Endoscopía; Cresta Ilíaca; Cadáver.*

INTRODUCTION

Endoscopic spine surgery has gained wide popularity among spine surgeons over the last decade. The adoption of this surgical technique is backed up by recent meta-analyses that favor lumbar endoscopic discectomy over microdiscectomy in clinical outcomes, duration of surgery, length of hospital stay, and lower risk of complications.[1,2] Initially seen as a tool for treating lumbar disc herniations, the range of applications for spine endoscopy expanded to the cervical and thoracic spine. Its use in treating foraminal, lateral recess, and central stenosis is increasingly common.[3,4] However, the benefits of an endoscopic approach go beyond decompression surgeries. Initial reports on endoscopically assisted fusion date back to the mid-1980s.[5] A recent meta-analysis comparing endoscopic assisted intraforaminal lumbar interbody fusion (iLIF) and minimally invasive transforaminal lumbar interbody fusion (MI-TLIF) has shown that for the treatment of lumbar degenerative diseases, iLIF has significantly less intraoperative blood loss and reduced length of hospital stay.[6] Although the iLIF technique has been gaining traction in L4L5 and the upper lumbar spine, the unique anatomy of L5S1 has limited the expansion of the technique in this segment. To overcome some of these limitations, a transiliac approach has been described to address disc herniations and stenotic pathology.[7,8] However, its reference to the iLIF technique is anecdotal.[8]

This study aims to demonstrate the feasibility of an L5S1 iLIF transiliac approach and to characterize the anatomic correlations of the endoscopic transiliac track.

MATERIALS AND METHODS

This study was approved by our institution's Review Board and the Ethics Committee (nr.68/2019/CEFCM).

Five randomly selected fresh-frozen human cadavers (four males, one female; mean age 77.6 years old [range: 64-87 years old]) with intact lumbar spines from L1 to S1 were used. Anatomical structural integrity was confirmed by standard anteroposterior (AP) and lateral fluoroscopic imaging of the lumbar spine and pelvis. All specimens exhibiting signs of vertebral fracture, spine tumors, previous lumbosacral surgery, spinopelvic congenital anomalies, or lumbar scoliosis were excluded. The included specimens were thawed at room temperature (23º Celsius) approximately 10 hours before testing.[9] Transiliac iLIF and supra iliac iLIF were performed bilaterally at L5S1. A total of 20 procedures were completed.

Each specimen was placed in the prone position on a radiolucent table. Under C-arm fluoroscopy, the main anatomic landmarks were identified and marked: the spinous process line, iliac crest line, medial pedicular line, and L5S1 disc space. The AP view was standardized so that the spinous processes of L5 and S1 were centered, and the inferior endplate of L5 and the superior endplate of S1 were parallel. In the lateral view, the inferior endplate of L5 and the superior endplate of S1 were also parallel, the pedicles overlapped, and to prevent rotation, it was ensured that the posterior vertebral line of L5 and S1 had a single contour.

On the right side, the transiliac procedure was performed first, and then the supra iliac procedure. On the left side, the order of the procedures was reversed; the supra iliac was the first to perform.

Transiliac procedure

1. The intersection of the lines collinear to the disc space in the AP and the lateral views determined the skin entry point. 2. A Jamshidi needle was inserted down to the iliac bone, aiming at the center of the disc space. The iliac crest was identified, and then the tip of the Jamshidi needle was slightly slid to the wing of the ilium. Using a rotation maneuver, the needle progressed through the thin cortical bone of the ilium with low to moderate pressure. 3. It was then advanced to the superior articular process (SAP) while aiming at the center of the disc space and keeping the trajectory parallel to the S1 superior endplate in the AP and lateral views. 4. After reaching the SAP, the needle progressed smoothly until the posterior ligament. At this point, AP and lateral view shots are obtained to ensure that the needle tip is in the medial half of the interpedicular line (AP view) and dorsal to the posterior vertebral line (lateral view). The needle further progressed, aiming at the center of the disc in both views. 5. The guidewire was inserted, and the Jamshidi needle was removed. 6. Dilators and reamers were sequentially introduced over the guidewire and used to perform a foraminoplasty under fluoroscopic guidance, with care not to overcome de medial pedicular line in the AP view and the posterior wall of the vertebral body in the lateral view. 7. Blunt bone drills were sequentially introduced to prepare the endplates until the height of the disc was matched. Care was taken to avoid excessive pressure and endplate fracture. The final bone drill was used as a reference for cage size 8. Sequential dilators and a working channel were placed over the guidewire, and the endoscope was introduced. Disc material was removed, and endplate preparation was completed under direct visualization. Endplate integrity was also confirmed. Foraminal debris was removed. Exiting nerve root (ENR) and traversing nerve root (TNR) were identified and decompressed as needed, making sure the foraminal and extraforaminal area was released and that there was enough space for cage deployment. In cases with foraminal stenosis, the SAP was further resected using a diamond burr or Kerrison rongeur. 9. The guidewire was reintroduced through the endoscope, and removed all the instruments. The cage was then hammered over the guidewire under fluoroscopic guidance. The aim was to place the cage parallel to the endplates, as anteriorly and centered as possible. 10. The guidewire, dilators, working channel, and endoscope were reintroduced. The final endoscopic revision was made to check cage placement, ensure ENR and TNR integrity, and decompression of the foraminal and extra-foraminal area.

Suprailiac procedure

1. The intersection of the lines collinear to the disc space in the AP and the lateral views also determined the skin entry point. 2. The Jamshidi needle was introduced, aiming at the center of the disc space. Then, the following steps were described for the transiliac procedure, steps 3. to 10.

The following measurements were standardized and recorded:
1. Distances from the transiliac track to the: 1) iliac crest; 2) posterior superior iliac spine (PSIS); 3) superior gluteal neurovascular bundle (Figure 1);
2. Pelvic incidence, sacral slope, and pelvic tilt;
3. Axial, sagittal, and coronal approach angles (Figure 2);
4. Cage's lateral and coronal center point ratio[10] (Figure 3);
5. Percentage of the cage crossing the AP and lateral view midline.

After the implants' remotion, the endplates' integrity was assessed through endoscopic visualization. Anatomic dissection was then performed, and the facet joint, sacroiliac joint, iliolumbar ligament, and exiting and traversing nerve roots were checked for integrity.

Statistics

Data are presented as mean, standard deviation (SD), and range. Mean differences were determined using the paired sampled t-test, using the significance level $\alpha = 0.05$. IBM SPSS 26[11] was used for the analyses.

RESULTS

There was no statistically significant difference between the procedures performed on the right side (transiliac approach performed first) and the ones performed contralaterally (transiliac approach performed after the supra iliac approach).

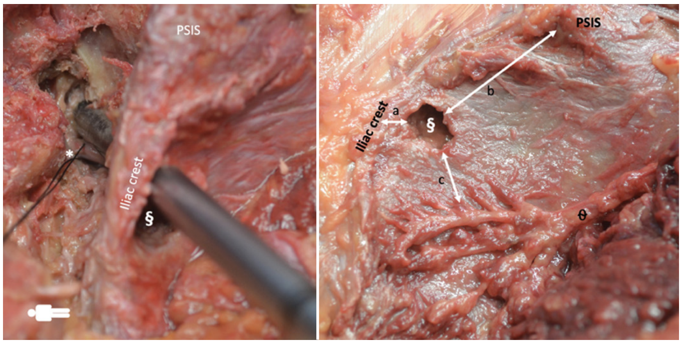

Figure 1. Distances from the transiliac track to the a) iliac crest, b) posterior superior iliac spine (PSIS); c) superior gluteal neurovascular bundle. § Trans-iliac track, * L5 nerve root, ϑ superior gluteal neurovascular bundle.

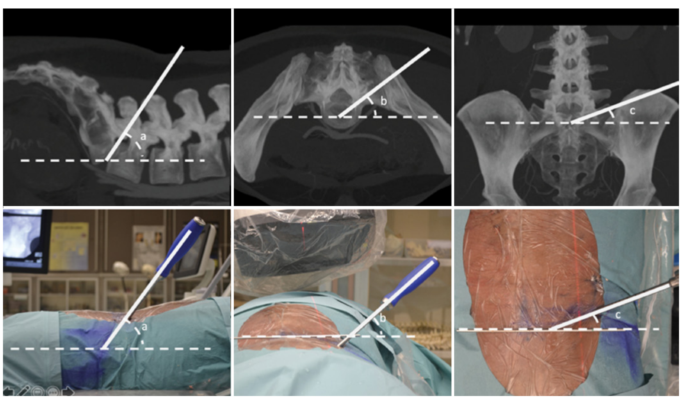

Figure 2. Measurement of sagittal(a), axial(b), and coronal(c) approach angles.

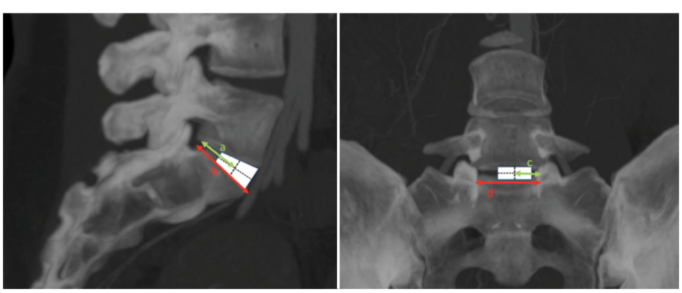

Figure 3. Lateral CPR = a/b; coronal CPR =(c/d).

In the transiliac procedure, the mean distance of the transiliac track to the iliac crest was 1.39±0.39 cm, to the PSIS 5.75±0.71cm, and the superior gluteal neurovascular bundle 3.62±0.88cm. (Figure 1, Table 1). The pelvic parameters are summarized in Table 1.

The axial and coronal approach angles were significantly decreased by 13.5^{o}(95% CI -15.5;-11.5; p value < 0.001) and 13.2^{o}(95% CI -15.3;-11.1; p value < 0.001), respectively , in the trans-iliac procedure. The sagittal approach angle was significantly increased by 5.4^{o}(95%CI 1.8,8.9; *p-value* = 0.008) in the trans-iliac approach (Table 2).

The AP CPR was significantly higher (MD 0.16; 95% CI 0.12,0.20; *p-value* < 0.001) in the trans-iliac approach. The percentage of the cage that crossed the midline in the AP view was also increased by 31.6% (95% CI 19.8,43.4; *p-value* < 0.001). Analysis of the lateral CPR and the percentage of the cage that crossed the midline in the lateral view showed no statistically significant difference between the two approaches. (Figure 4)

No endplate fractures were identified. In addition, the integrity of facet joints, sacroiliac joints, iliolumbar ligament, and exiting and traversing nerve roots was maintained.

DISCUSSION

We conducted a cadaver study to determine the feasibility of the transiliac approach for the iLIF technique in L5S1. We also compared the surgical technique and cage final position between the supra iliac and the transiliac approach to L5S1.

The main finding is that both the supra iliac and the transiliac approach succeeded in preserving the integrity of the studied anatomic structures, namely, facet joints, sacroiliac joints, iliolumbar ligament, exiting, and traversing nerve roots. However, by removing the shift caused by the iliac crest in the transiliac approach, the implant had a more central position in the coronal plane without compromising the anterior placement of the cage. This was achieved without disrupting the iliac crest, the PSIS and with superior gluteal neurovascular bundle preservation. The decreased axial and coronal angles and the increased sagittal angle allow a more anatomic track, making it easier to overcome the unique challenges of L5S1. In addition, it eases the placement of the implant in a centered position, in contrast with a more lateral placement in the supra iliac track.

Previous studies have shown the safety and efficacy of the iLIF.[6] However, the transforaminal endoscopic approach to the L5S1 disc space has been a challenging issue for a long time. The correlation with the iliac crest, the relatively narrower foramen and larger facet joints, the L5 dorsal root ganglion (DRG) anatomy, and the slope of the disk space have been pointed out as some of the limiting factors.[12,13] According to our findings, most constraints can be overcome with a transiliac approach without compromising the surrounding anatomic structures.

Further studies should determine which patients are most suited for a transiliac approach. Although the transiliac approach potentially decreases the risk of L5 nerve root traction and injury, special care must be taken with the L5 DRG when attempting this approach.

Table 1. Distances from the transiliac track to the iliac crest, PSIS, superior gluteal neurovascular bundle, and pelvic parameters.

N		△ Iliac crest	△ PSIS	The superior gluteal neurovascular bundle	PI	SS	PT
1	1R	1.4	7.1	2.8	48.9	21.1	27.8
2	1L	1.2	6.7	3.1	48.9	21.1	27.8
3	2R	1	5.7	3.4	51.2	23.1	28.1
4	2L	1.1	5.3	3.7	51.2	23.1	28.1
5	3R	1.4	6.1	4	55.8	21.7	34.1
6	3L	1.7	5.9	3.6	55.8	21.7	34.1
7	4R	0.9	5.1	2.6	57.9	40.6	17.3
8	4L	1.2	4.9	2.9	57.9	40.6	17.3
9	5R	2.1	5.5	5.3	46.5	24.4	22.1
10	5L	1.9	5.2	4.8	46.5	24.4	22.1
Mean±SD (Range)		1.39±0.39 (0.9,2.1)	5.75±0.71 (4.9,7.1)	3.62±0.88 (2.6,5.3)	52,06±4.74 (46.5,57.9)	26.18±8.16 (21.1;40.6)	25.88±6.4 (17.3,34.1)

Numbers in rows are mean, standard deviation, and range, in centimeters; Abbreviations: PSIS, posterior superior iliac spine; PI, pelvic incidence; SS, sacral slope; PT, pelvic tilt; SD, standard deviation; △Distance from the transiliac track.

Table 2. Approach angles and cage positioning measurements.

	θ axial	θ sagittal	θ coronal	CPR AP	% cross midline AP	CPR Lateral	% cross midline lateral
Trans	33.28±6.0 (24.7,43.8)	58.59±3.72 (50.8,63.3)	19.77±3.08 (13.9,23.1)	0.51±0.03 (0.45,0.55)	51.6±3.8 (0.46,0.57)	0.54±0.03 (0.47,0.60)	55.6±6.1 (40.8,65.0)
Supra	46.79±5.64 (40.9,57.5)	53.23±2.83 (48.3,57.8)	32.99±4.73 (25.8,40.2)	0.35±0.08 (0.25,0.48)	20.04±17.80 (0.0.52.5)	0.52±0.06 (0.41,0.60)	51.58±7.41 (41.8,64.2)

Numbers in rows are mean, standard deviation, and range; Abbreviations: CPR, center point ratio; AP, anterior-posterior; θ, angle; %, percentage.

CONCLUSION

The transiliac iLIF in L5S1 is a feasible surgical technique. It allows a more centrally placed interbody cage in the coronal plane without compromising the anterior position in the lateral plane. In addition, the integrity of the major anatomic structures at risk was preserved in a step-by-step approach.

Availability of data and material (data transparency)

The datasets generated during and analyzed during the current study are available from the corresponding author upon reasonable request.

All authors declare no potential conflict of interest related to this article.

CONTRIBUTIONS OF THE AUTHORS: JMS, HR, and JGC made substantial contributions to the conception and design of the work; All authors made substantial contributions to the analysis and interpretation of data; JMS, JG, and JGC drafted the work; All authors revised it critically for important intellectual content.

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