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Study of degenerative (non-lytic) spondylolisthesis grade 1 and 2 in axial MRI images

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ABSTRACT

Background: The traditional imaging assessment of lumbar spondylolisthesis is in sagittal images noting movement of upper body over the lower body. It omits change at the facet.
Methods: The present observational, study included 35 patients with degenerative lumbar spondylolisthesis(non-lytic). Radiological analysis of all MRI images was done by 4 independent spinal surgeons and 2 radiologists. The study focused on the axial MRI images and changed relation between the superior articular process and inferior articular process and relation between inferior articular process and canal with thecal sac (traversing root).
Results: Majority of DS had sagittal oriented facets (71.43%). In 7 cases at the L3/4 and in 19 cases at L4/5 level both facet joints had sagittal orientation with forward (ventral) movement of IAP. The IAP was found to be encroaching or in close proximity of traversing root. In 1 patient at L3/4 and 6 patients at L4/5 joint was sagittal unilaterally, may be causing compression of the neural elements unilaterally, while on coronal side the IAP and SAP had a normal alignment and not causing neural encroachment
Conclusions: We need to concentrate on relation of IAP vs SAP at facet as seen in axial images of facet.

Keywords: Facet joint orientation, Degenerative non-lytic spondylolisthesis, MRI

INTRODUCTION

Degenerative spondylolisthesis is slip of one vertebral body over the one below. Whole upper vertebra (vertebral body and posterior part of the vertebra including neural arch and processes) slips relative to the lower vertebra.[1] Functional flexion/extension radiographs are considered the gold standard for diagnosing the presence of degenerative instability in the setting of spondylolisthesis.[2] In 1938, Meyerding described classification with respect to L5-S1 level for spondylolisthesis (lytic).[3] In 1954 Taillard described a grading system as based on the standing lateral radiograph as percentage of displacement of the cephalad vertebral body on the caudad body, which is a modification of the Meyerding classification.[4] This displacement is used for classification and treatment decisions but has not yet been able to explain symptom generation. The movement of IAP at facet joint towards central canal may contribute to symptoms where its presence in close proximity of traversing nerve has to be demonstrated. The traditional imaging assessment of lumbar spondylolisthesis (DS) is in sagittal images noting movement of upper body over the lower body. It omits change at the facet. Sagittal image over emphasizes anterior column structures. We concentrated on changes at facet joints in axial images rather than coronal or sagittal images. This was done to focus purely on changes at facet and in close proximity of traversing nerve entering the lateral recess (subarticular area) that may explain symptoms. Present study is based on study of facet joints

in axial images in spondylolisthesis with respect to: orientation (sagittal vs. coronal) of facets at the level of listhesis in axial images. Any movement of IAP towards the central Canal of the spinal segment in axial images, as a part of spondylolisthesis. Using this facet subluxation, grade it for better imaging classification of DS. Symptom generation and treatment related algorithm is not part of our present study.

Objectives

Spondylolisthesis is associated with translation of whole vertebra over lower one affecting canal and its contents giving symptoms. Objective of current study was to concentrate not on symptoms but purely on imaging in this study, to study position of Inferior Articular Process (IAP) (medial Facet) and its relation to SAP (Superior articular process**)** in degenerative (non-lytic) Spondylolisthesis and propose classification system based on relation of position of IAP with respect to neural tissues ventral to it in canal.

METHODS

Study design, duration and location

The present observational, study included 35 patients with degenerative lumbar spondylolisthesis (non-lytic). Study was conducted from February 2023 to February 2024 at BKL Walawalkar Rural Medical College & Hospital, Dervan, Maharashtra, India.

Inclusion criteria symptomatic patients of DS

Both male and female symptomatic patients above 40 years with degenerative lumbar spondylolisthesis (non-lytic), Grade 1 or 2 as per standard classification were included.

Exclusion criteria

Cases with all other causes of Lumbar Spondylolisthesis namely lytic, dysplastic, traumatic were excluded.

Procedure

The sample size was calculated using convenience sampling (all patients with DS in the study time period with MRI scans were included in the study). All patients underwent a standing radiograph in flexion extension, followed by a supine MRI of the lumbar spine. Radiological analysis of all MRI images was done by 4 independent spinal surgeons and 2 radiologists. In supine position there is reduction in slip as compared to weight bearing position. All MRI were 1.5 T and above used. The study focused on the axial MRI images and changed relation between the superior articular process (SAP) and inferior articular process and relation between inferior articular process and canal with thecal sac (traversing root). We also measured forward movement of IAP with respect to SAP by drawing a line over both SAP tip (cut 5 axial image). All the images having DS were analyzed. 8 cuts for axial images were planned on the sagittal images at the affected level. These corresponded with: 1-lower border of cranial pedicle, 2-between pedicle and inferior end plate of cranial vertebra, 3-inferior end plate of cranial vertebra (this is seen at the level of tip of SAP), 4-mid-disc level, 5-lower disc level or superior end plate of caudal vertebra, 6-Upper border of caudal pedicle, 7- mid pedicle of caudal and 8-lower border of caudal pedicle. The facet joints are anatomically from cut number 3-7.

The facet joint extends from inferior end plate of superior vertebra to mid pedicle across line of lower vertebra. As mentioned previously 8 cuts need to be planned on the sagittal images, cut 3-7 corresponds with the entire height of facet. To simplify and standardize we have taken all measurements at cut number 5 (mid facet level). Anteriorly it has Traversing Nerve Root (TNR), laterally foramen and posteriorly lower facet pole. However, to study all minute details we have to study all cuts from 3-7 in detail. A detailed analysis of these cuts was done for Orientation of the facets and Relation of IAP to SAP at specified level that is mid facet joint in axial plane. WE have taken cut number 5 at lower disc endplate or the upper endplate of the lower vertebra. Thecal sac may carry floating roots but at the level of cut 5 the traversing nerve root is immobile, (at the site of entry to the root canal which is also start of the lower zone or lateral recess). Based on these axial images, we were able to further comment on encroachment of facets towards the thecal sac (traversing root). We drew a line along the bilateral SAP of facet joint and noted if IAP has travelled towards central canal. The distance in mm from line base to tip of IAP as seen in this axial cut is to be measured. Facet tropism was defined on the basis of the landmark article- the facet orientation circle published by Verbiest et al in-Spine Journal in 1997.[5]

Statistical analysis

The collected data was coded and entered in Microsoft Excel sheet. The data was analyzed using SPSS (Statistical Package for social sciences) version 20.0 software. The results were presented in tabular and graphical format. For Qualitative data various rates, ratios and percentage (%) was calculated. For Quantitative data Mean, SD, Median etc. was calculated.

RESULTS

The (Table 1) shows distribution of patients according to age. It was observed that majority of patients were in age group >60 years followed by 41-60 years. Majority of patients were female (60%) and males were 40%. Majority of patients were at L4-5 level (71.43%) followed by L3-L4 (25.71%), followed by L5-S1(2.86%) (Table 2). It was observed that majority of patients were present with Grade I (91.43%) followed by grade II (8.57%) lumbar spondylolisthesis. Majority of DS had sagittal oriented facets (71.43%). In 7 cases at the L3/4 and in 19 cases at

L4/5 level both facet joints had sagittal orientation with forward (ventral) movement of IAP (Table 3).

Table 1: Age and sex distribution.

Parameters	N	%
Age group (years)		
41-60	11	31.4
>60	24	69.6
Sex		
Male	14	40
Female	21	60

Table 2: Level of lumbar spondylolisthesis.

Cause	N	%
L4-5	25	71.43
L5-S1	1	2.86
L3-4	9	25.71

Table 3: Facet joint orientation.

Parameters	N	%
Sagittal	25	71.43
Coronal	3	8.57
Facet tropism	7	20.0

Table 4: IAP protruding beyond SAP Line.

Parameters	N	IAP crossing SAP line
Sagittal	32	32
Coronal	3	0

The IAP was found to be encroaching or in close proximity of traversing root. In 1 patient at L3/4 and 6 patients at L4/5 joint was sagittal unilaterally, may be causing compression of the neural elements unilaterally, while on coronal side the IAP and SAP had a normal alignment and not causing neural encroachment.

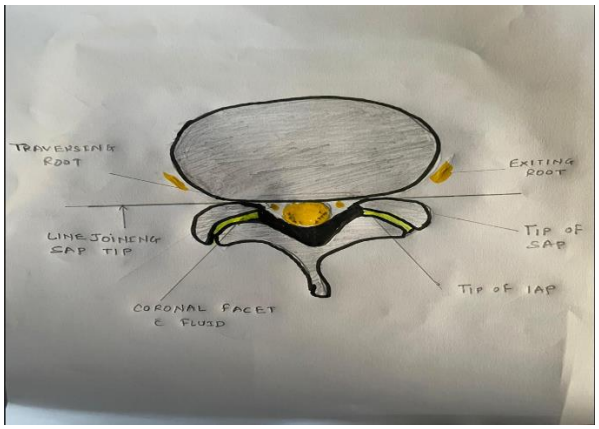

Figure 1: Schematic diagram showing coronal facet with SAP line.

The above table (Table 4) shows that at all the sagittal oriented facets the IAP was protruding beyond the SAP line (on axial image cut number 5). In case of coronal joint orientation IAP was not protruding beyond ventral SAP line and was associated with fluid in joints. Below depicted diagrams, (Figure 1-2) are schematic representations, showing Coronal facet with ventral SAP line and the relation between IAP and SAP and, movement of IAP and its close proximity to neural structures respectively. The (Figure 3), is an axial MRI image in DS showing ventral movement of IAP beyond SAP line.

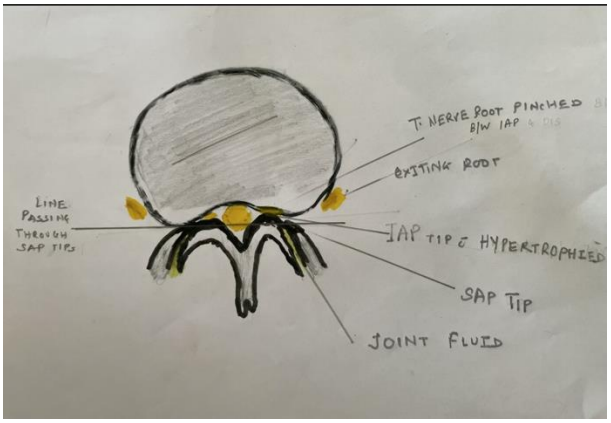

Figure 2: Schematic diagram showing movement of IAP and its relation with neural elements.

Figure 3: MRI image in DS showing ventral movement of IAP beyond SAP line.

DISCUSSION

We have described the MRI findings on the basis of the 3 zone 3 wall concept described previously by senior author.[6] Concept is upper zone canal is within confines of upper body and contains the exiting root and the dorsal root ganglion (DRG) (cut number 1-3). Whole zone moves in front in listhesis. The middle zone is canal behind the disc level and is posterolaterally covered by facet and contains thecal sac with floating nerve roots, there is no free nerve in foramen in middle zone (cut number 4-5). The lower zone is within confines of lower body and

contains the traversing root that is immobile at entry to root canal or lateral recess (cut number 6-8). Movement of IAP (part of upper vertebra) is noted at this level. Facet joints are influential factors in the development of lumbar degeneration, including disc herniation and non-lytic lumbar spondylolisthesis. Facet orientation (FO) and facet tropism (FT) are two important structural parameters of the lumbar facet joints. Disc stress is concentrated on the ipsilateral region of facet joint with greater sagittal orientation when FT existed.[7]

In previous study pronounced sagittal alignment of facet joints in patients with listhesis represents a secondary remodeling rather than a pre-existing morphology. Facet joint asymmetry does not seem to play a major role in the development of listhesis.[8] In a later study patient with degenerative spondylolisthesis had more sagittal orientated facet joints ($p<0.01$) and more significant facet joint tropism ($p<0.05$) than normal control subjects. Morphological abnormalities of the lumbar facet joints are a predisposing factor in the development of degenerative spondylolisthesis.[9] Our study supports this. We are still not aware if facet related changes are a cause or an effect. We have been able to demonstrate significant movement of IAP with respect to SAP at facet joint in listhesis. This movement may not occur in cases where facets are 45 degree or coronal but then facet may show signs of micro-instability such as fluid/ effusion/ open facet sign. We feel we may be able to explain why decompression alone may work in DS based on our understanding of IAP vs. SAP movement and compression in start of lateral recess. In a study long-term follow-up result revealed that satisfactory clinical outcomes were obtained with decompression alone, without fusion, for patients with lumbar spinal stenosis and degenerative spondylolisthesis, grade 1 and 2 listhesis. It probably is highlighting importance of compression by IAP in symptom generation rather than instability part. And removal of IAP has given symptomatic relief.[10]

Chen et al performed a meta-analysis of four randomized controlled trials and 14 nonrandomized controlled studies including 77,994 patients to compare decompression alone (7,878 cases) and decompression with fusion (70,116 cases).[11] Their conclusion was that among patients with lumbar degenerative spondylolisthesis, decompression with fusion did not yield better clinical outcomes than decompression alone. Also, the complication rate and reoperation rate were comparable between the two treatment groups. However, patients who underwent decompression alone had shorter operation time, less intraoperative blood loss, and shorter hospital stay.[11] Our studied understanding is that decompression alone may be effective as it relieves changes in proximity of entry to lateral recess (cut 5) in axial images. We are aware that exiting nerve and DRG is not likely to be relevant as upper zone has already moved away as a block from the canal thus widening the canal and may be decompressing the theca. When we reduce the listhesis paying attention not only to restoring body position but facet position IAP vs. SAP will be significant. A survey amongst 26 consultant spinal surgeons of varying experience was conducted. The survey focused on; symptom generators in degenerative spondylolisthesis, The importance of the facet joint orientation in degenerative spondylolisthesis, Indications for fusion/non fusion decompression degenerative spondylolisthesis. 24 out of 26 (92.30) did not have a satisfactory explanation to the above questions. Only 2 out of 26 were able to answer and had an understanding of the anatomy involved in degenerative spondylolisthesis. This makes us feel our focus on facet joint and IAP vs. Sap may need more attention.

Based on our understanding of facet, we recommend as a concept (though unproven yet) standalone decompression (open/ endoscopic) in cases of coronal facets, while in the case of sagittal facets the decompression should be supplemented with instrumented fusion. Patients with disc pathology with associated non lytic listhesis with non-sagittal facet orientation irrespective of the grade of listhesis based on Meyerding classification, surgical options of discectomy(endoscopic) alone may be enough. Treatment for non-lytic listhesis is based on reduction of the translation of the vertebral body (cranial over caudal) without focus on facet joint. If the orientation of the facet is sagittal with a ventrally protruding IAP the chances of progression of the listhesis appear to be higher and treatment should involve reduction of slip and removal of medial facet (supplemented with Fixation). If the facet is coronal in orientation the chances of progression of slip is minimal and the use of instrumentation (pedicle screws) is such cases is debatable. If we are contemplating removal of IAP alone, it may be possible to achieve transforaminally by endoscopy using drill and curettes under local anesthesia. Kirkaldy-Willis and Farfan state that advancing segmental degeneration follows a course from stable to dysfunctional, unstable to re-stabilized. Most important factor for re-stabilization seems to be formation of hook-shaped osteophytes of the facet joints, associated with severe osteoarthritis (Grade 3), which leads to an interlocking between the vertebrae. We feel that unstable joints are more sagittal and auto stability is not likely.[12] The study of correlation between effusion of the facet joints on MRI and difference in the degree of slippage between the standing and lying positions on x-ray in patients with DS showed increasing effusion size increased the probability of having DS. This seems to be more seen with non-sagittal joints. The sagittal joints slip more.[13] We feel that a semi coronal or 45-degree facet joint will not allow movement of IAP vs. SAP and will be having more of effusion. Our study and its focus have brought to the fore “Iap will be moving forward in cases of listhesis” in sagittal facet orientation where it is less likely to see more effusion but actual movement. This significance of facet orientation cannot be seen on sagittal images and may be missed completely. Our “G” Line drawn on ventral sap face will help us in noting the movement of IAP and its severity in mm on cut 5 on axial imaging.

Bartynski's classification has been described for Lateral Recess Stenosis.[14] Based on our 8 cuts this classification is based on Cut number 6 and 7. We would like to distinguish this and our findings even though if we consider symptoms, they may be same. Our cut 5 is above beginning of lateral recess as we do not see pedicle as lateral wall in images. The facet orientation circle article describes the orientation of facet joints in a transverse plane. The article is based on computed tomography images.[5] Based on the 8 cuts previously described these images are at the level of cut number 4. If we consider anatomy of posterior wall of lateral recess and also at cut 5, we note that it is formed by SAP and ligamentum flavum. IAP is completely dorsal to ligamentum flavum. Lower attachment of ligamentum flavum is on upper edge of lower lamina and IAP is always dorsal to this at its lower pole. If in our axial image study, we see IAP jutting in the canal it is likely to have perforated the ligamentum flavum. The correlation to symptoms needs to be further evaluated.

Limitations

Limitations of current study were; this study is based on radiological analysis, does not consider the symptomatology, no high-grade spondylolisthesis (Grade 3 & 4) was included in this study and Does not include surgery and resultant post operative imaging.

CONCLUSION

We need to concentrate on relation of IAP vs SAP at facet as seen in axial images of facet. This may explain symptoms better as close proximity of moved IAP to traversing root may be the causative factor. More studies are warranted about the clinical implications of this by noting pre-and post of images and clearance of the area of compression and involvement in spondylolisthesis.

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Ethical approval: The study was approved by the Institutional Ethics Committee

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