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Distraction of facets with intraarticular spacers as treatment for lumbar canal stenosis: report on a preliminary experience with 21 cases

Clinical article

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Object. The authors report their experience in treating 21 patients by using a novel form of treatment of lumbar degenerative disease that leads to canal stenosis. The surgery involved distraction of the facets using specially designed Goel intraarticular spacers and was aimed at arthrodesis of the spinal segment in a distracted position. The operation is based on the premise that subtle and longstanding facet instability, joint space reduction, and subsequent facet override had a profound and primary influence in the pathogenesis of degenerative lumbar canal stenosis. The surgical technique and the rationale for treatment are discussed.

Methods. Between April 2006 and January 2011, 21 cases of lumbar degenerative disease resulting in characteristic lumbar canal stenosis were treated in the authors' department with the proposed technique. The patients were prospectively analyzed. There were 15 men and 6 women who ranged in age from 48 to 71 years (mean 58 years). Nine patients underwent 1-level and 12 patients underwent 2-level treatment. Surgery involved wide opening of the articular joint, denuding of the articular capsule/endplate cartilage, distraction of the facets, and forced impaction of Goel intraarticular spacers. Bone graft pieces obtained by sectioning the spinous processes were placed within and over the joint and in the midline over the adequately prepared host area of laminae. The Oswestry Disability Index and visual analog scale were used to clinically assess the patients before and after surgery and at follow-up. The alterations in the physical architecture of spinal canal and intervertebral foramen dimensions were evaluated before and after placement of the intrafacet implant and after at least 6 months of follow-up.

Results. All patients had varying degrees of relief from symptoms of local back pain and radiculopathy. Impaction of spacers within the facet joints resulted in an increase in the spinal canal and intervertebral root canal dimensions (mean 2.33 mm), reduction of buckling of the ligamentum flavum, and reduction of the extent of bulge of the disc into the spinal canal. The procedure resulted in firm stabilization and fixation of the spinal segment and provided a ground for arthrodesis. No patient worsened neurologically after treatment. During the follow-up period, all patients had evidence of segmental bone fusion. No patient underwent reexploration or further surgery of the lumbar spine.

Conclusions. Impaction of the spacers within the articular cavity after facet distraction resulted in reversal of several effects of spine degeneration that had caused spinal and root canal stenosis. The safe, firm, and secure stabilization at the fulcrum of lumbar spinal movements provided a ground for segmental spinal arthrodesis. The immediate postoperative and lasting recovery from symptoms suggests the validity of the procedure.
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Key Words • **lumbar canal stenosis** • **Goel intraarticular spacer** • **radiculopathy**

Lumbar canal stenosis has been treated successfully for decades by using a variety of nonsurgical and surgical methods. We report a novel method of treatment of lumbar degenerative disease that involves a technique of facet distraction and fixation. The rationale for treatment using the proposed technique is the observation that degenerative lumbar canal stenosis results from longstanding and subtle vertical spinal instability. This instability initially causes reduction of the facet joint space and subsequent facet override. Facet instability, rather than disc degeneration, could be the primary pathogenic factor that initiates a cascade of events, ultimately resulting in spinal canal stenosis.[4] Facet distraction, as proposed, aims to restore and fuse the facets in their normal alignment. The technique has resulted in remarkable clinical recovery and in reversal of several pathological events in the lumbar spine that are associated with degenerative/spondylotic lumbar canal ste-

This article contains some figures that are displayed in color online but in black and white in the print edition.

nosis. We present and analyze our experience with the technique. We recently discussed facet distraction as a modality of treatment for cervical spondylotic disease,[5] and on the basis of our observations with the technique, we have discussed the philosophy of possible pathogenesis of spondylotic disease.[4,5] We had earlier analyzed the morphological features of facets of the lumbar spine that are relevant to the proposed surgical technique.[1,9–11] Biomechanical issues pertaining to the technique are under assessment.

The experience is preliminary and is based on a relatively small series of patients. The validity of the technique will have to be assessed on the basis of a larger clinical experience and studies that can compare the outcome with other widely accepted and successfully used techniques.

Methods

Between April 2006 and January 2011, we treated 21 cases of lumbar degenerative spinal disease using the proposed technique. The patients had characteristic lumbar degenerative disease that resulted in manifestations of lumbar canal stenosis. These patients were analyzed prospectively. There were 15 men and 6 women whose ages ranged from 48 to 71 years (mean 58 years). The clinical symptoms at the time of presentation are elaborated in Table 1. All 21 patients had axial back pain and characteristic neurogenic claudication pain. No patient had any focal neurological deficits. The patients had progressive neurological symptoms and failure of nonoperative management. All patients underwent dynamic (flexion and extension) plain radiography, CT scanning, and MR imaging before and after surgery. Patients who exhibited instability on dynamic images that demonstrated grossly abnormal mobility or resulted in any degree of spondylolisthesis were not considered suitable for this surgical technique and instead underwent conventional fixation surgery with pedicle screws and rods. Essentially, the indication of the proposed surgery was for patients who had characteristic clinical and radiological features of lumbar canal stenosis without any evidence of radiologically observed instability, bone destruction, or fusion. Patients with an acute disc herniation or an extruded disc fragment were not considered for treatment by the technique. Nine patients underwent 1-level and 12 patients underwent 2-level treatment. The presenting clinical symptoms, radiological features, and outcomes are listed in Tables 1–4. The Oswestry Disability Index[3] and visual analog score[6] were used to evaluate the patients before and after surgery and during follow-up of at least 6 months. All radiographic measurements were taken with the back in neutral position. The radiographic analyses that were performed included measurement of maximum intervertebral foramen height, facet height, and interlaminar distance. The intervertebral disc space height was measured at 3 levels: the anterior limit, the midpoint, and posterior limit of the vertebral bodies (Table 4).

Operative Technique

The patient was placed in the standard prone position that flattened the lumbar lordosis. A midline incision was made, and using subperiosteal dissection, the articular joints were exposed widely on both sides. The spinal level of the surgery was confirmed with the aid of intraoperative fluoroscopy. On direct observation and manipulation, the involved articulation had a lax articular capsule; there was a subtle facet override and evidence of incompetence of the joint. These findings were valuable and were correlated with clinical symptoms and findings on images while considering the levels and extent of fixation. The articular capsule was opened and the facets were distracted using varying sizes of osteotomes that were introduced with their flat-sharp edge and then turned 90° to affect distraction. The flexed position of the spine obtained during surgery aided in facet distraction and postural reduction. Essentially, the instability is vertical in nature and distraction involved superior elevation of the facet of the rostral vertebra. Distraction aims to restore the normal alignments of the facets and dimensions of the canal. The articular capsule and endplate cartilage was widely denuded using a screwing motion of the osteotome and, whenever necessary, using a micro drill. The Goel intraarticular spacers were then impacted within the joint cavity using a specially designed impactor. The spacers are shown in Fig. 1. They are made of medical-grade titanium and are 2–3.5 mm thick and 8–12 mm in diameter. Spacers with a height of 2.5 mm and a diameter of 10 mm were most often used. The surfaces of the spacers adjacent to the articular surface of the facets were spiked to provide stability to the implant. The spacer impactor has a screw-thread design that holds the implant, directs its introduction, and controls its traverse. The interspinous process ligaments are then widely removed. Bone graft is obtained following sectioning of the adjoining spinous processes and placed over the appropriately prepared host bone area of laminae. Since the goal of the operation is arthrodesis of the spinal segment, the patient is placed on bed rest for a period of 8 weeks. Only minor activities are

TABLE 1: Table showing the presenting clinical and radiological features of 21 patients undergoing facet distraction with intraarticular spacers

Parameter	Value
sex	
male	15
female	6
median age (yrs)	58 (48–71)
symptoms	
back pain	21
intermittent claudication	18
level of involvement	
L2–3	6
L3–4	12
L4–5	18
L5–S1	3
no. of levels distracted	
1	9
2	12

TABLE 2: Oswestry Disability Index

Score (%)	No. of Patients	
	Preop	6 Mos Postop
10–20	0	14
20–30	6	4
30–40	6	3
40–50	5	0
50–60	4	0

permitted during this time with lumbar restraint. After this period, and confirmation of spinal fusion, all routine activities are permitted.

Results

In 2 cases, insertion of the spacer was possible only on one side. This occurred because the spacer on one side pushed and obliterated the contralateral facet joint space. This problem was encountered in 2 patients who were treated during the initial phases of our experience. Introduction of an appropriate-sized spacer after simultaneous distraction-elevation of facets on both sides assisted in preventing such an incident.

The follow-up period ranged from 6 to 37 months (mean 17 months). Neurological and radiographic assessments were performed by observers independent of the principal surgeon (A.G.). The clinical outcome of surgery is elaborated on in Tables 2–4. There was no incidence of misplacement or dislodgment of the implant. All patients improved to varying extents with regard to symptoms after surgery. The degree of improvement was evaluated using the Oswestry Disability Index and visual analog scale (Tables 2 and 3). The evaluation included the location and degree of preoperative and postoperative pain using an analog scale. Student t-tests were used to compare preoperative neurological status with follow-up assessment of at least 6 months. A p value < 0.05 indicated a statistically significant difference. The operation was not repeated, and additional surgery was not performed at the same surgical level or at any other lumbar spinal level in any case. There were no implant-related complications. All radiological measurements were made using calipers. Morphometric measurements were performed before and after placement of the intraarticular spacers. The changes in the dimensions of the intervertebral spaces are elaborated on in Table 4. On MR images, there was clear evidence of reduction of the posterior disc bulge and ligamentum flavum indentation into the spinal canal, resulting in an overall increase in the spinal canal dimensions (Fig. 2). Fusion of the spinal segment was defined as the absence of all kinds of motion and alterations in the interlaminar and intervertebral body distances on flexion-extension radiographs obtained at a follow-up of at least 6 months. As per this criterion, successful fusion was obtained in all the treated spinal levels. None of the patients underwent reexploration of the region or needed any additional surgical procedure for the lumbar spine.

TABLE 3: Visual analog scale scores*

Time Point	Back Pain VAS Score
preop	7.8 (5–9)
3 mos postop	2.4 (0–3)
6 mos postop	0.8 (0–1)

* A score of 0 denotes no pain, whereas a score of 10 denotes maximum pain. Abbreviation: VAS = visual analog scale.

Discussion

Lumbar spinal degeneration that leads to lumbar canal stenosis is a disabling clinical condition. The pathogenesis has been well described in the literature.[1,2,7] The most accepted view of pathogenesis is that it is related to a cascade of processes that start with degeneration of the disc due to dehydration or herniation. We recently reported our successful experience with the treatment of 36 cases of cervical spondylosis with facet distraction.[45] On the basis of our experience, we presented an alternative hypothesis of pathogenesis of spondylotic disease and identified that facet degeneration, reduction of the interfacet distance or facet telescoping, and the subsequent instability or incompetence, probably related to muscle weakness, had a profound impact on the pathogenesis of the entire spectrum of spondylosis.[4] Following this primary event, there occurs loss of disc space height, bulge of the posterior anulus/posterior longitudinal ligament, infolding of the ligamentum flavum, and similar such events that ultimately lead to stenosis of the spinal canal and intervertebral neural foramina. Facet hypertrophy, as frequently observed in lumbar canal stenosis, appears to be a physical manifestation of facet overriding and the resultant articular capsule laxity. The symptom of back pain could also originate from the facet joint. The symptom of claudication pain may be related to muscle fatigue on walking and resultant exacerbation of facet override. The technique of facet distraction essentially aims to restore the natural anatomical spacing of the spinal segments. Distraction and fixation of the facets might result in alleviation of dynamic and pathological events that are associated with lumbar spinal degeneration.

The lumbar facets are more vertically aligned than the relatively horizontally and obliquely aligned facets of the cervical and thoracic spine. The orientation of the facets is different at different spinal levels and differs even in

TABLE 4: Radiological parameters

Parameter	Mean in mm (range)		
	Preop	Postop	Increase
facet height	2.8 (1–4.5)	5.75 (4.5–11.9)	3.11
foraminal height	10.14 (6–16)	12.52 (10.5–19)	2.38
interspinous height	6.95 (3–13)	8.38 (3.5–14)	1.42
disc space height			
anterior	5.26 (3–8.5)	6.71 (5.5–8.5)	1.45
middle	4.69 (3–6)	6.35 (5–8)	1.66
posterior	4.09 (2–6)	5.11 (3.5–7.5)	1.02

Fig. 1. Photograph showing the various sizes of the spacers. The flat surface has serrations to make the surface rough. The hole with serrations on the side of the implant is meant for the spacer holder. The hole in the center of the flat surface is meant to assist in arthrodesis.

the cranial and caudal lumbar levels. In the more cranial levels, the facets were oriented more sagittally and vertically, and in the caudal lumbar vertebrae the orientation was more coronal and horizontal. The facets of the cranial segments (L2–3) are oriented closer to the midsagittal plane of the vertebral body, whereas those of the caudal lumbar segments (L4–5) are oriented farther away from that plane.[9] The distraction of the facets of the lumbar spine essentially involves superior elevation of the articular facet of the rostral vertebra. Distraction of the lumbar facets results in horizontal and vertical increases in the spinal canal size. Essentially, the technique reverses the overriding of facets and restores the articular height and the spinal canal and root canal dimensions. The symptoms of canal stenosis are reversed after the surgery. The procedure of distraction of the facets results in an increase in the intervertebral body distance, restoration of disc water content, and decrease in the posterior bulge adjacent to the disc. The stretch of the ligamentum flavum could be directly observed during facet distraction, suggesting that the ligament is not hypertrophic but only buckled. The interspinous process distance also increased. Essentially, decompression of the neural tube and nerve roots is achieved without the removal of any part of bone, ligaments, or disc.

The insertion of the spacer within the articular cavity is technically relatively straightforward and significantly safer than insertion within the articular cavity of the cervical spine. The lumbar articular cavity is more circumscribed, providing a safe placement and preventing migration of the implant. Moreover, the pedicles of the inferior vertebra form an anterior limit that restricts the traverse [migration] of the spacer toward the spinal canal or toward the root. There was no need for intraoperative fluoroscopy to determine the adequacy of insertion of the spacer as it could be maneuvered under direct vision, and the extent and direction of insertion of the spacer could be regulated by the spacer impactor. The bone material of the facets was thick, strong, and largely cortical. Osteoporosis of the bone that might affect performing some other surgical procedures such as interspinous spacer placement and pedicle screw insertion usually does not preclude performing our operation. The procedure can be done in isolation or it can be used as a supplement to all other techniques. In addition, the procedure can be performed when other midline methods of fixation or decompression have failed. The size of the implant is relatively small, and the use of large metal implants extending over multiple levels, as are used in some described stabilization techniques, can be avoided. As the nature of the implant and the material used is rather straightforward, the hardware cost can be significantly less than that for implants currently in commercial use.

Lumbar canal stenosis has been treated by a variety of nonsurgical and surgical methods. Decompression of the lumbar spinal canal by laminectomy has stood the test of time, is still considered to be a gold standard in treatment, and is used by most surgeons. Traction of the neck and back has been used for more than a century in the management of spondylotic disease. The effectiveness of such a treatment method can be gauged by its lasting popularity and clinical success. Bone-preserving or saving methods have recently found favor. Spinous process[12] and laminar distraction[8] techniques using specially designed implants are currently gaining increasing popularity (Richards J, Majumdar S, Lindsey DP, et al: Quantitative changes in the lumbar spinal canal with an interspinous implant. Paper presented at the Ninth International Meeting on Advanced Spine Techniques, Montreaux, Switzerland, May 23–25, 2002). It appears that the techniques for treatment of lumbar canal stenosis using vertebral body cages or interspinous process spacers are successful as they provide stabilization in a distracted position. Placement of an artificial disc also distracts the spinal segment to a considerable extent to restore the intervertebral body distance. We observed that the extent of increase in the interspinous process distance with our technique was similar to that obtained by the interspinous process spacers that have recently become popular. However, placement of spacers within the joint resulted in a significantly more stable and firmer stabilization than placement of interspinous process spacers or intervertebral cages, which are more liable for displacement and failure. The spacers provided a firm stabilization of the region and, although possible, an additional need for instrumented fixation was not found to be necessary.

In contrast to other methods of treatment in which the patient is mobilized immediately following surgery, we limited the patient's activities for a period of 8 weeks. The spinous process was sectioned at its base, and bone graft pieces thus obtained were placed in the midline and over the facets for bone fusion. Although limiting the movements of the patients is against the general contemporary norm of quick mobilization and early resumption of routine activities, it appears to us that segmental bone athrodesis in a distracted position was an important component of the operation. It formed the basis of long-term stability of the spinal segment and of the implant. As the implants are placed at the site of fulcrum of spinal

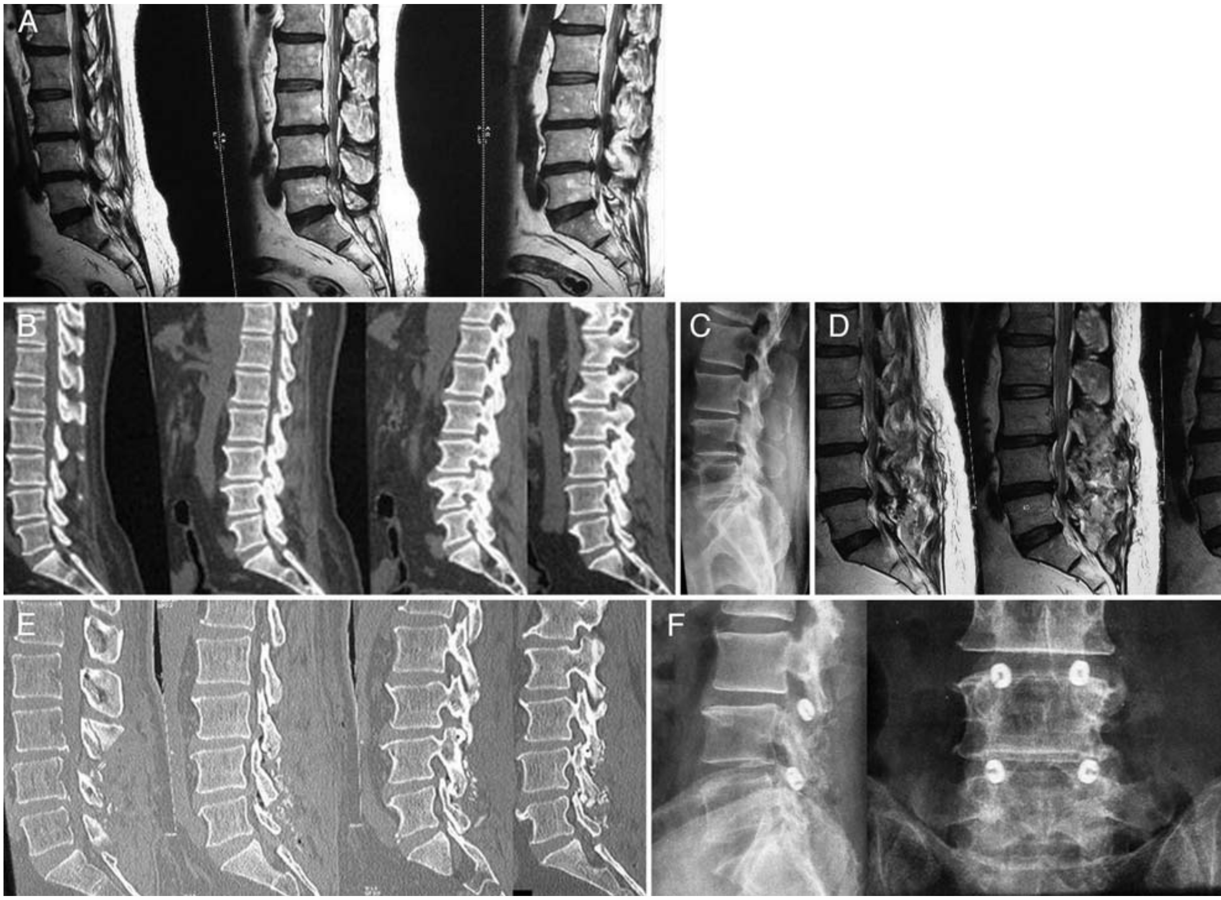

Fig. 2. Images obtained in a 63-year-old man. **A:** Preoperative T2-weighted MR images showing evidence of lumbar canal stenosis more prominently at L3–4 and L4–5 levels. **B:** CT scans showing spinal and root canal stenosis. **C:** Preoperative plain lateral radiograph. **D:** Postoperative MR images showing marginal reduction in the indentations opposite the L3–4 and L4–5 disc space. **E:** Postoperative CT scans showing an increase in the disc space height and interlaminar distances. The increase in the spinal canal and foraminal canal dimensions can be observed. Intraarticular spacers can be observed. **F:** Plain radiographs showing the intraarticular spacers.

movements, they provide remarkable stability. However, pedicle screw fixation can simultaneously be carried out, a procedure that could obviate the need for or reduce the duration of bed rest. The reversal of several pathological features of spondylosis after distraction of facets and our successful result provide validity to this hypothesis.

The technique resulted in demonstrated improvements in symptoms of pain. In no case did we observe recurrent disease, pseudarthrosis, hardware failure, or migration. There were no wound infections or host rejections of instrumentation. The drawback of this study is that a comparative cohort of patients who had undergone either a traditional surgery or other minimal invasive techniques was not included. Moreover, the exact inclusion/exclusion criteria for deployment of the technique will need to be assessed, evaluated, and determined on the basis of further experience. The need for postoperative restriction of activities is a drawback and will have to be counted in the overall assessment of the technique.

Conclusions

From our experience we conclude that intraarticular spacers can be effectively used in the treatment of lumbar canal stenosis. Joint distraction using spacers can be a stand-alone method of treatment or can be used in combination with other fixation methods and provides critical increase in space for dural tube and roots and a firm stabilization in such cases.

We believe that the proposed technique is a safe and rational alternative to all conventional forms of treatment for patients having single or multilevel lumbar canal stenosis. There is certainly a scope for further improvement in the type of implant and techniques of their deployment.

Disclosure

The authors report no conflict of interest concerning the materials or methods used in this study or the findings specified in this paper.

Author contributions to the study and manuscript preparation include the following. Conception and design: Goel. Acquisition of data: Shah, Jadhav, Nama. Analysis and interpretation of data: Goel, Shah. Drafting the article: Goel, Shah. Critically revising the article: all authors. Reviewed submitted version of manuscript: all authors. Approved the final version of the manuscript on behalf of all authors:

Goel. Statistical analysis: Shah. Administrative/technical/material support: Goel, Jadhav, Nama. Study supervision: Goel.

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