

Editorial

Relevance of Goel’s hypothesis regarding pathogenesis of degenerative spondylosis and its implications on facet distraction surgery

Atul Goel

Department of Neurosurgery, King Edward Memorial Hospital and Seth Gordhandas Sunderdas Medical College, Parel, Mumbai, Maharashtra, India

Corresponding author: Dr. Atul Goel, Department of Neurosurgery, King Edward VII Memorial Hospital and Seth G. S. Medical College, Parel, Mumbai - 400 012, Maharashtra, India. E-mail: atulgoel62@hotmail.com

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The subject of spondylosis or spinal degeneration has been under evaluation for over a century. A number of authors have analyzed the subject, resulting in a variety of treatment methods being successfully employed. Disk material alteration and “decay” has been uniformly incriminated to be the primary initiator of the process of spinal degeneration. The phenomenon of “subsidence” or reduction in the intervertebral spaces has been related to the process of reduction in the water content of the disk. It has generally been considered that there is a progressive reduction in the water content of the disk after 30 years of age. The reduction of the water content of the disk and alteration in its chemical composition makes the disk material smaller, more fibrous, and less elastic. The annulus fibrosus in the normal course is not weight bearing and nucleus pulposus or the disk material itself bears the entire burden. Whilst the vertical weight bearing is dependent on nucleus pulposus, the annulus fibrosus restrains the nucleus pulposus by maintaining transverse and horizontal pressure. However, with the reduction in the disk size, annulus fibrosus may also be a part of weight bearing complex and is likely to bulge into the spinal canal due to its inherent weakness and potential inability to bear the extra burden. The phenomenon results in circumferential buckling of the spinal ligaments and osteophyte formation in a manner similar to “callus” formation in fractured bone segment secondary to loosening or separation of periosteum from bone surface in a phenomenon referred to as “periosteal reaction.” The osteophyte formation is a

result of primary release of ligamentous membranes from the edges of the disk, facets, and uncovertebral joints and secondary, probably reparative, and naturally stabilizing bone formation. The existing concept is that subsidence at the level of the disk is manifested by secondary changes and listhesis of the facets.

Degenerative spondylosis has been described as an ageing process that is secondary to pathological degeneration of disk, bones, and ligaments. Generally, there is no or only a little mention of muscles or even instability in the entire process. Instead, Goel’s hypothesis of pathogenesis of spondylosis places the entire onus on incompetence or weakness of muscles that are responsible for standing human position and on “vertical” instability of the spine.^[1-3] The hypothesis that is the basis of Goel’s facet distraction surgery described in 2011 as a form of treatment of degenerative spine is based on the fact that muscle weakness due to varying factors leading to instability and telescoping of the vertebral elements appears to be primary factor in the entire process of degeneration.^[4,5] Accordingly, instability could be the primary factor in the pathogenesis of degenerative spondylosis and secondary “pathologic” spondylotic changes of disk, bones, and ligaments. Goel’s hypothesis regarding pathogenesis of spondylosis also states that disk size reduction or loss of its water content is not the primary issue in the degenerative process and disk affection is only secondary to facet listhesis – a result of muscle weakness. The disk space reduction is a form of compensatory or secondary mechanism that occurs as a response to the facet listhesis. In general, disk is fluid in its nature and reduction or displacement of fluids in the event of a mass invasion or local or remote instability is a known phenomenon.^[6,7] Restoration of the disk space height and of its water content has been demonstrated after facet distraction surgery.^[4,5]

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Buckling of the ligaments in the degenerative process has been interpreted in a variety of manners. Whilst most authors consider ligamentous hypertrophy to be a part of the primary degenerative and pathologic phenomenon, some authors find such ligamentous thickening only to be buckling secondary to reduction in the disk space height. Vertical telescoping of the vertebral segments seems to be an obvious cause of the ligamentous buckling. Restoration of the inter-vertebral distances as a result of facet distraction surgery provides a real-time opportunity to visualize normalization of dimensions and turgidity of ligaments. However, facet distraction surgery aims at arthrodesis of the spinal segment and does not restore function of the ligaments. Efforts are to introduce an artificial joint in the facet joints bilaterally instead of an artificial intervertebral body disc.

Osteophyte formation has been uniformly identified to be a pathologic event that is secondary to disk space height reduction. Osteophytic compression of the spinal cord and the nerve root has been identified to be the principal cause of symptoms in spondylosis. The treatment of spondylosis is generally focused on dealing with the osteophytes and the removal of the compression due to them. Goel's hypothesis of spondylosis states that osteophytes are not primary phenomenon and develop secondary to ligamentous laxity as a result of facet arthrosis. It also states that following the distraction of the facets, there is a potential for progressive disappearance of the osteophytes. The concept is that osteophytes do not need primary treatment and the surgical treatment that is directed toward this end may be avoidable or is unnecessary.

Several articles mention thickening of the laminae, spinous processes, and articular facets in the event of spinal degeneration. Accordingly, decompression or removal of offending bone forms an important component of surgical treatment. Decompressive laminectomy and foraminotomy form a major form of treatment for degenerative spine. Facet distraction surgery avoids the removal of any part of the bone and decompression is achieved primarily by realignment of the facets and restatement into normal position. Following facet distraction there occur decompression of the entire spinal segment, spinal canal, and neural foramina. Goel's facet distraction surgical treatment avoids the removal of any part of the bone, ligaments, osteophytes, or disk. Essentially the procedure achieves distraction arthrodesis of the affected spinal segment in a distracted or realigned naturally normal position. The aim of treatment is to stabilize and realign the unstable and "collapsed" spinal segment.

Real time assessment of facet instability is possible during surgery. Assessment of facet stability in the segments adjoining the levels of surgery can be done by direct visualization and manipulation whenever there is a significant doubt. The facet distraction of the spinal segment may be necessary due to the presence of instability and can be done even when there is no clear radiological evidence of local cord compression. Such a surgery on the affected facet can avoid the issue of adjacent segment degenerative problems that are frequently seen following disk space surgery that is based essentially on radiological interpretation.

The facet distraction surgery can be a straight-forward and simple operation that can even be performed per-cutaneously and with needle sized instruments using fluoroscopy or with an endoscope. Anterior cervical surgery that involves retraction of major blood vessels and oro-tracheal complex can be entirely avoided by the procedure. A number of authors have recommended discectomy, partial and complete corpectomy, and similar such major surgical procedures for the purpose of decompression of the spinal cord and neural foramen. Such decompression is safely and easily possible by the facet distraction surgery. The surgical procedures like artificial disk insertion seem to provide clinical relief due to their potential of distraction of vertebral bodies and vertebral segments.

We proposed that basilar invagination and atlantoaxial dislocation are secondary to "vertical instability" of the region or telescoping of the facets and proposed facet distraction and stabilization as treatment.^[8] Such treatment essentially reduces both basilar invagination and atlantoaxial dislocation and also stabilizes the instability that is the basis of pathogenesis. Essentially, stabilization of the atlantoaxial region forms the foundation of treatment. On the basis of this hypothesis, we proposed that any form of bone or soft tissue decompression that includes transoral decompression, foramen magnum decompression, or resection of retro-odontoid ligament may not be required in such cases. We also hypothesized that instability is the primary event and all other features like basilar invagination, atlantoaxial dislocation, osteophyte formation, and retro-odontoid bone hypertrophy are secondary events.^[8] Treatment of primary pathology avoids the needs to treat any secondary events.

The principle of facet distraction surgery of the subaxial spine simulates to a great extent the facet distraction surgery of the atlantoaxial region proposed by Goel as treatment for basilar invagination and craniovertebral instability. Except in relatively rare clinical situations, the instability at craniovertebral junction is generally synonymous with atlantoaxial dislocation. Degenerative arthritis of the craniovertebral junction is essentially "telescoping" of the facets of atlas and axis that result in the reduction of the space or cavity of the articular joint and simulates reduction in the intervertebral joint space in degenerative disk disease. Considering the natural alignment of the facets of atlas and axis, such reduction in the joint space can result in subtle basilar invagination and "fixed" or "irreducible" atlantoaxial dislocation. The lordotic curvature and variations in the alignment of the facets at each spinal level result in variation in the pattern of arthrosis at each spinal level. The superior facet in craniovertebral region dislocates anteriorly whilst the superior facet of the subaxial cervical spine dislocates posteriorly. Due to their relatively vertical alignment, in case of lumbar spine, the inferior facet dislocates inferiorly in relationship to the superior facet of the adjoining vertebra. Osteophytes in the proximity of the atlantoaxial facets simulating the osteophytes adjoining degenerative disk spaces in subaxial spinal spondylosis are frequently identified in good quality imaging, and signify the presence of facet degeneration and instability. Retro-odontoid "pseudotumors" or ligamentous hypertrophy is a commonly identified pathology and seems to be

related to osteophytes in their pathogenesis and indicate instability of the craniovertebral junction. Goel first hypothesized that the presence of retro-odontoid ligamentous hypertrophy or bone osteophyte formation is a clear suggestion of instability of the region and pointed toward the need for atlantoaxial stabilization surgery. He also suggested that direct handling or removal of the retro-odontoid tissue was not necessary. Subsequently, several authors have shown regression of the retro-odontoid tissue following surgery that aims only at stabilization of the atlantoaxial region. Instability of the atlantoaxial region forms the primary basis of formation of osteophytes, reduction of the size of the articular cavity, and listhesis of the facets. Understanding of this basic and essential element in the pathogenesis of basilar invagination can lead to rationalization of surgical treatment that should aim primarily at stabilization and secondarily to morphological realignment. Our analysis on the subject, based on a large number of cases confirms the view that decompression of the odontoid process or resection of the rim of foramen magnum has no role in the management of basilar invagination. Distraction of the facets with the help of bone graft with or without the assistance of metal spacer aims for realignment of the craniovertebral junction, brings the odontoid process inferiorly and anteriorly, and reduces both basilar invagination and atlantoaxial dislocation.^[9-12] Similar concepts are relevant in the treatment of pathologic events related to degenerative spine. The presence of facetar listhesis, reduction in the inter-facetar space, osteophyte formation, reduction in the foraminal height, and canal size and the disk space height are all secondary to the primary pathology of instability focused at facets that is secondary to muscle supporting the physical form of the body in standing or erect position. Like in craniovertebral junction or atlantoaxial region, facetar distraction, and fixation

appear to be a rational and philosophical form of treatment for degenerative stenosis of the spinal canal and neural foramina.

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