potential problems reduce the desirability of spinal laminectomy and make this operation unsuitable for some elderly patients with significant, pre-existing medical problems.

Correction of spinal stenosis through lengthening of the spinal pedicles has recently been described (US Patent No.s 8,157,847, 7,166,107 and 6,358,254) and involves a novel surgical procedure of cutting and lengthening the spinal pedicles using an implanted medical device which is able to enlarge the spinal canal and alleviate the symptoms of spinal stenosis. Pedicle lengthening is much less invasive compared to spinal laminectomy and is capable of achieving a permanent expansion of the spinal canal. However, because the anatomy of the spinal pedicles varies throughout the lumbar spine and also between individuals, it would be desirable to have an implant capable of adapting to these anatomic variations. In particular, in situations where the vertebrae with a high convergence angle of the pedicle, such as is often seen at the L5 level, pedicle lengthening produces an offset or lateral shift between the upper and lower bone segment at the site of the pedicle osteotomy (bone cut).

For the foregoing reasons, there is a need for an improved device to accommodate the variations that may be encountered in pedicle anatomy and to allow offset between the upper and lower bone segments at the site of the pedicle osteotomy.

SUMMARY OF THE INVENTION

~~The~~ Embodiments of the present invention provides several novel devices allowing improved accommodation of the variations in pedicle anatomy and allowing for the offset between the upper and lower bone segments of a vertebra occurring at the site of a pedicle osteotomy. The devices according to embodiments of the present invention are particularly pertinent when a subject pedicle has high convergence angle. The various embodiments disclosed herein involve a series of implantable devices having an upper and a lower portion bridged by a longitudinal (inner) member. All embodiments provide

for neutralization of medially directed force vectors, and enhancement of anteriorly directed force vector, during a pedicle lengthening process.

Embodiments of the present invention ~~will be seen variously~~ may be able:

- to provide a simple and safe methods and implants for performing percutaneous pedicle lengthening, ideal for accommodating variations in vertebral anatomy; and in particular for achieving pedicle lengthening in situations having high convergence angle between the pedicles;

- to allow optimal lengthening of the pedicles in vertebrae with high convergence angles between the pedicles;

- to enhance the work flow and efficiency of the percutaneous pedicle lengthening procedure;

- to improve the biomechanical strength of the fixation of the pedicle lengthening device; and

- to neutralize the medially directed force vectors produced by pedicle lengthening when there is convergence between the pedicles.

In one aspect of the invention, an implant for expanding a spinal canal is provided that includes an upper portion and a lower portion, each having an inner bore. The inner member is configured to communicate with a swivelable coupling at each end thereof. Each swivelable coupling can interact with a respective upper or lower portion, within the inner bore thereof. Movement of the inner member relative to one or both of the upper and the lower portions, via one or both swivelable couplings, translates the upper portion away from the lower portion, about a vertebral cut, to widen the vertebral cut, and expand the spinal canal. The swivelable action of the couplings during translation allows angulation of the inner member, relative to a longitudinal axis of the implant, to accommodate a change in shape of a vertebra during vertebral cut widening.

The inner bore of each of the upper and the lower portions could be conically shaped to accommodate angulation of the inner member during translation. Inner member angulation

widened inner bore of the upper portion in a direction from a proximal end of the widened inner bore to and finally abutting against a distal end of the widened inner bore.

This aspect might also include a retaining lock nut, threadably engaging inner walls of the widened inner bore of the upper portion, to advance and move the bulbous end of the inner member in the upper portion within the widened inner bore and to finally secure the bulbous end of the inner member in the upper portion against the distal end of the widened inner bore to secure the upper portion relative to the lower portion, after translation, to secure and maintain a width of the widened vertebral cut.

In a further aspect, an implant could include an upper portion, and lower portion and an inner member. The upper portion might include in an inner bore an upper coupling fixed therein but configured for swiveling. The upper coupling could have an internally threaded passage therethrough. The lower portion might include in an inner bore a lower coupling fixed therein but configured for swiveling. The inner member could be fixedly attached at one end to the lower coupling, with threads at the other end for engagement with the internally threaded passage of the upper coupling. Threadable movement of the inner member relative to the upper coupling causes the inner member to translate the upper portion away from the lower portion, about a vertebral cut, to widen the vertebral cut. The swivelable action of the upper and the lower couplings allows angulation of the inner member, during translation, allowing for a lateral shift of the upper portion relative to the lower portion naturally occurring during widening of the vertebral cut, thereby accommodating a change in shape of a vertebra during expansion of the spinal canal.

In a still further aspect, an implant could include an upper and a lower portion, each having an internal passage. In this aspect, at least one of the upper portion internal passage or the lower portion internal passage is offset from a central longitudinal axis of the upper and the lower portion. The implant further includes an inner member in communication with the upper and the lower portion. Movement of the inner member in relation to the upper and the lower portion causes the inner member to translate the upper portion away from the lower portion,