Zucherman JF, Hsu KY, et al. A prospective randomized multi-center study for the treatment of lumbar spinal stenosis with the X STOP interspinous implant: 1-year results. Eur Spine J 2004;12:22-31.

Design: Randomized clinical trial

Population/sample size/setting:

- 200 patients (109 men, 91 women, mean age 69) treated for lumbar spinal stenosis at 9 centers in the United States
- Eligibility requirements were age 50 or older with leg, buttock, or groin pain (with or without back pain) relieved during flexion, able to sit for 50 minutes without pain, walk at least 50 feet, and have at least 6 months of nonoperative treatment
- Stenosis was confirmed by CT or MRI at 1 or 2 levels
- Exclusion criteria were fixed motor deficit, cauda equina syndrome, significant lumbar instability, previous lumbar surgery, significant peripheral neuropathy or denervation from nerve root involvement, scoliosis > 25°, spondylolisthesis > Grade 1, sustained pathologic fractures, osteoporosis, obesity, Paget's disease, or steroid use more than 1 month in the past 12 months

Main outcome measures:

- Allocation of treatment was by block randomization by an individual not involved in treatment to either X STOP (n=100) or to nonoperative treatment (n=100)
- X STOP group received the spacer on an outpatient basis under local anesthesia with fluoroscopy to confirm operative level
- Nonoperative group received at least one epidural steroid injection; in addition, they could receive NSAIDs, analgesics, and physical therapy
    - PT consisted of back school and modalities such as ice, heat, massage, pool therapy, and stabilization exercises
    - Braces (abdominal binders) and corsets were allowed, but body jackets and chair-back braces were not
- Main outcome was the Zurich Claudication Questionnaire (ZCQ) which captures 3 self-reported domains: symptom severity (best score=1, worst=5), physical function (best score=1, worst=4), and satisfaction after treatment (best score=1, worst=4)
- Treatment success was defined as meeting three criteria: a 0.5 point improvement in *both* symptom severity and physical function *and* a satisfaction score between 1 and 2.5
- All 100 patients randomized to X STOP received the intervention; 9 of the 100 randomized to control group withdrew immediately after learning they would not receive the X STOP device
- For the X STOP group, ZCQ data were available for 94 patients at 6 weeks, 88 patients at 6 months, and 88 at 1 year

- For the control group, attrition was greater: 72 had ZCQ data at 6 weeks, 63 at 6 months and 68 at 1 year
- ZCQ data are presented as bar graphs only; for each of the three domains at each of the three follow-up times (6 weeks, 6 months, 1 year) the X STOP group had greater improvement than the control group (around 75% of X STOP patients showing improvement vs. around 20-40% of control patients)
- For "success," the X STOP group had a 1 year success rate of 59% vs. 12% for the control group (numerical data reported in the discussion section, not in the results section)
- In addition to the ZCQ main outcome, the authors reported SF-36 scores for both groups, which were generally consistent with the improvements on the ZCQ scores and were generally better in the X STOP than in the control group

Authors' conclusions:

- X STOP is more effective than conservative treatment for lumbar spinal stenosis
- X STOP has a success rate similar to that of decompressive laminectomy

Comments:

- Most major threats of bias appear to have been controlled, except that blinding was not feasible
- Osteoporosis was an exclusionary criterion, but it is not specified how this was ruled out, nor whether there was a minimum bone density required for entry into the study
- The recruitment of patients is not specified; they may have been recruited through media advertising, through physician referral, or by some other means, making the source from which they came unclear
- Block randomization by site is useful in assuring that centers with considerable experience with X STOP do not, by the play of chance, have either too many or too few patients assigned to the experimental device
- Most of the outcomes are reported in bar charts, but the numerical data are not provided
- Although each nonoperative patient had at least one epidural steroid injection, the rest of the nonoperative protocol is not well described and may not represent optimal nonoperative treatment
- The patients had all undergone 6 months of conservative treatment without satisfactory resolution of symptoms; the experimental intervention is therefore being compared with an intervention which has already failed and whose continuance is not expected to be successful
- There was differential attrition between the two arms of the trial; in Table 2, 88 patients in the X STOP arm completed the ZCQ at 1 year, but only 68 control patients completed the ZCQ
    - Because 9 control subjects withdrew consent upon learning that they had not been randomized to X STOP, it is reasonable to say that they never became trial participants; the follow-up rates for X STOP is 88% and 75% in the control group

    - It is possible to do a sensitivity analysis on success rates from the data provided in the text
        - The success rate for X STOP was 59% (52 of 88 participants)
        - The success rate for the control group was 12% (8 of 68 participants), with 23 patients not accounted for; if all 23 were successes, the success rate for the control group is 31/68, or 46%
        - An advantage for X STOP would still be present, making the differential attrition an unlikely source of bias
- The numerical data iu Table 5 show that the control group had a baseline SF-36 score of 16.9 for vitality, but in Figure 9 the score is greater than 40; Table 5 is likely to be a misprint
- Tables 6 and 7, which compare X STOP to previous reports of laminectomy, do not have a straightforward interpretation; the laminectomy studies are heterogeneous and the populations may be significantly different
    - A head to head comparison of X STOP with laminectomy is in progress in Europe, but no data from that study are available
- The outcome measurement for functional gains includes an item for ability to walk more than 2 miles, but other items (walking around house, grocery shopping) may not capture the full range of activity which could be sought in a working age population

Assessment: Adequate for evidence that X STOP is likely to be superior to continuing nonoperative treatment after several months of conservative care has not resolved symptoms of neurogenic claudication due to spinal stenosis

Zucherman JF, Hsu KY, et al. A Multicenter, Prospective, Randomized Trial Evaluating the X STOP Interspinous Process Decompression System for the Treatment of Neurogenic Intermittent Claudication. Two-Year Follow-Up Results. Spine 2005;30:1351-1358.

Design, population, setting, and outcome measures are the same as in Zucherman et al 2004.

Two-year additional follow-up outcomes were reported:

- Data were available from 93 of 100 X STOP patients and from 81 of 91 non-op control patients
    - Of the 7 X STOP patients lost to follow-up, 4 died, 2 failed to complete the ZCQ, and 1 withdrew
    - Of the 10 control patients lost to follow-up, 3 died, 1 withdrew after the first epidural steroid injection, and 6 withdrew
- At 2 years, the mean improvements in the Symptom Severity scores of the ZCQ were 45.4% for the X STOP group and 7.4% in the control group
- For the Physical Function scores, the X STOP group had 44.3% improvement and the control group had 0.4% worsening

- The two-year scores for both groups were not different from the scores obtained at earlier follow-up time points: 6 weeks, 6 months, and 12 months
- At 24 months, the criteria for success were met by 48.4% of the X STOP group and by 4.9% of the control group
- 6 patients in the X STOP group underwent decompressive laminectomy; 24 patients in the control group underwent the same operation in the same time period, most of whom had improvements in symptom and function scales after laminectomy
- One X STOP patient died from complications of pulmonary edema which occurred 2 days after device implantation
    - There were 4 other wound and incision-site complications in the X STOP group in the days following surgery, none of which was major
    - 3 device-related failures occurred in the X STOP group: 1 implant dislodged after a fall, 1 asymptomatic spinous process fracture was detected at the 6 month radiographic exam, and 1 patient had worsening pain more than 1 year after the operation
    - In addition, 1 X STOP implant was malpositioned posteriorly
- Three factors were associated with success in the X STOP group: a positive femoral stretch test, a lack of comorbid conditions, and less surgical blood loss
- The presence of spondylolisthesis was not associated with the success of the X STOP implant; 56% of the 34 patients with spondylolisthesis were successes, and 44% of the 59 patients without spondylolisthesis were successes ($p>.05$)

Authors' conclusions:

- X STOP is a safe and effective treatment for neurogenic intermittent claudication compared to nonoperative treatment

Comments:

- As above, with the notation that some of the control group patients who did not contribute data to the 1 year follow-up ZCQ scores did contribute data to the 2-year follow-up
- The low device failure rate in the setting of a clinical trial should be compared to the failure rate in a larger and less restricted patient population

Anderson PA, Tribus CB, Kitchel SH. Treatment of neurogenic claudication by interspinous decompression: application of the X STOP device in patients with lumbar degenerative spondylolisthesis. J Neurosurg Spine 2006;4:464-471.

Design, population, setting, and main outcome measures are the same as in Zucherman 2004 and 2005

- The only difference in outcome measurement between Anderson and Zucherman is that Anderson normalized the ZCQ symptom and function scores were normalized on a 100-point scale, keeping patient satisfaction measured on a 5 point scale

- The criteria for success were very similar to those of Zucherman et al

This study reports on the subgroup of the Zucherman RCT which had some degree of spondylolisthesis (n=75); the criteria for inclusion in this analysis were at least 5° and a maximum of 25° of slippage as determined by lateral radiographs

Two-year outcomes for the group with spondylolisthesis were:

- For the X-STOP group (n=33), the success rate was 63.4%; for the control group (n=45), the success rate was 12.9%
- Slippage and lordotic angulation did not change between the baseline and the 24-month follow-up radiographic measurements
- The complications were a subset of those reported in Zucherman 2005

Authors' conclusions:

- The X STOP implant improves symptoms and physical function for neurogenic claudication from lumbar spinal stenosis with spondylolisthesis, without significantly changing slippage or angulation of the involved segments

Comments:

- The Anderson study could have been reported as an additional table in the Zucherman studies, and is not a separate trial on an independent population
- There is a discrepancy between the allocation of treatment reported in Table 1 and in Table 4
    - In Table 1, there are 42 X STOP patients and 33 control patients; in Table 4 these numbers are reversed
    - Since Zucherman 2005 reported on 34 X STOP patients having spondylolisthesis, Table 4 is likely to present the correct numbers
    - Zucherman 2005 reports a 56% success rate for 34 X STOP patients (n=19); Anderson reports a 63.4% success rate in 33 patients (n=21)
    - This is likely to be due to small differences in accounting between the two reports, and does not affect the conclusions
- Importantly, the three articles could have been reported as a single article reporting the 2-year results of one RCT, with an additional table for the patients with spondylolisthesis, who did not differ from the patients without slippage

Assessment: Adequate for some evidence that X STOP is superior to continuing nonoperative treatment in patients with neurogenic claudication due to lumbar spinal stenosis when 6 months of conservative treatment have not resolved symptoms and improved function