3D Printing – An Aid to Neuromodulation

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Background

3D printing, also known as additive manufacturing or rapid prototyping, describes a technology where a computer-aided design (CAD) is fabricated in a layer-by-layer fashion. Being able to interact hands-on with a 3D-printed haptic biomodel enables superior visuospatial appreciation of the patient's unique anatomy and aids in individualized preoperative planning and is being integrated into the preoperative clinical workflow in many medical disciplines.

Aim

To explore the application of 3D printing in the preoperative planning of for the trial and implantation of a spinal cord stimulator in a patient with challenging spinal anatomy and to assess the feasibility of a successful epidural needle placement and lead insertion.

Method

Thin-slices (0.625 mm) of a high resolution CT scan of the patient's thoracolumbar spine and iliac crests was used to create a computer-aided design (CAD) model on 3D Slicer software (Surgical Planning Laboratory, Boston, MA). The CAD file was exported and converted into a 3D printer-friendly file using MarkerBot Desktop software (MakerBot, New York, NY). The model was printed using a desktop 3D printer MakerBot Z18 (MakerBot, New York, NY).

Case

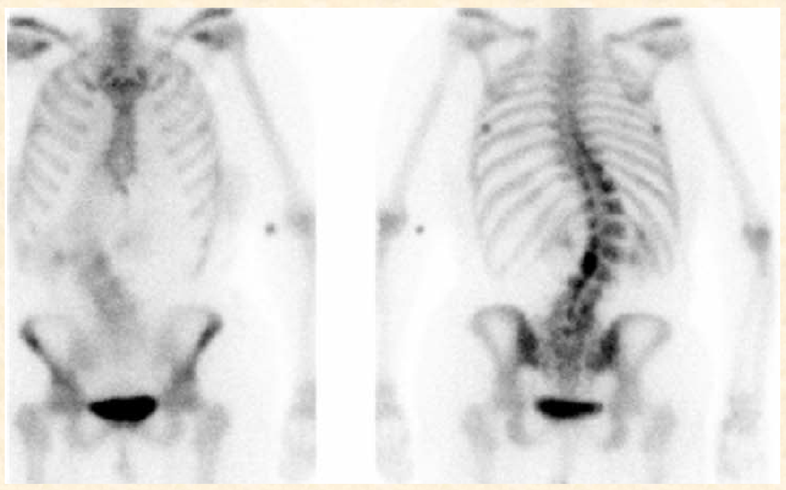
DW 73F, with severe kyphoscoliosis, osteoporosis and a long story severe back pain that occasionally radiated to her right leg.

Her relevant story includes unhelpful blocks, peripheral field nerve stimulator and failed percutaneous spinal catheter insertion.

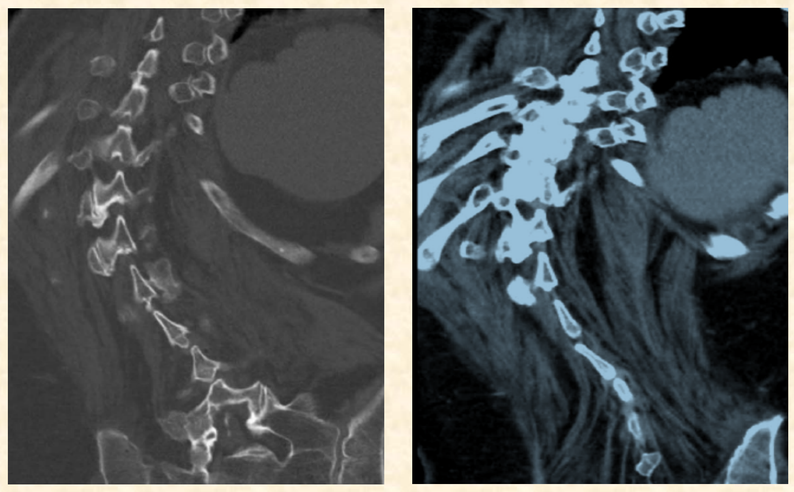
Pain related medications included meloxicam, duloxetine 60mg mane, docusate sodium,/senna 50/8mg 2-4 daily, nitrazepam 5mg nocte, Oxycodone 5mg IR tds prn, oxycodone/naloxone 30/15mg bd, paracetamol SR 1330mg tds, pregabalin 150mg bd, and prednisolone. Norspan, venlafaxine, TENS, baclofen, tapentadol, burst IV and regular oral ketamine, clonazepam, uncomfortable back brace, ultrasound guided right trochanteric bursa injection had been tried without success

Activity was severely restricted by pain and she was less active and was resting in bed much of the time. She said her pain averaged 8/10, had been 5-8/10 in the preceding 24 hours. She said her current treatment relieved none of her pain. Pain related interference with activities of daily living was scored 45/70 on the Brief Pain Inventory. Indicating moderate-severe pain and moderate interference with daily activity.

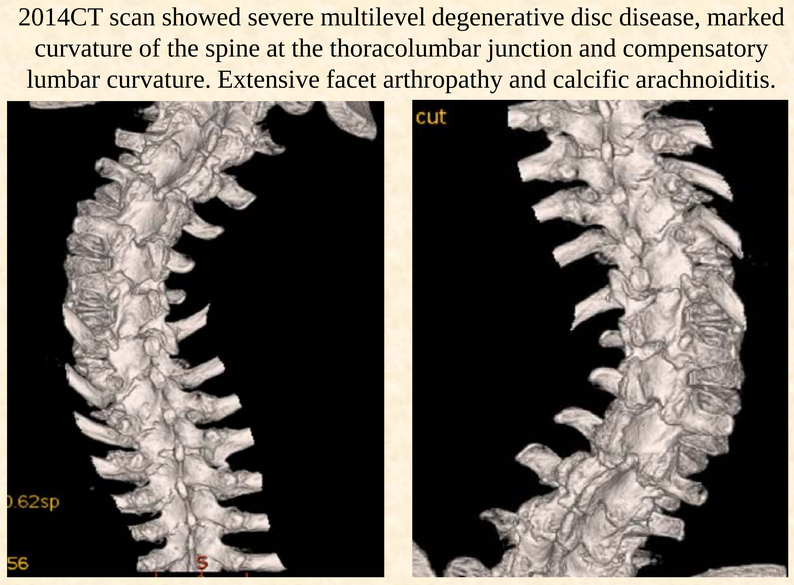
A MRI was contraindicated by her pacemaker.



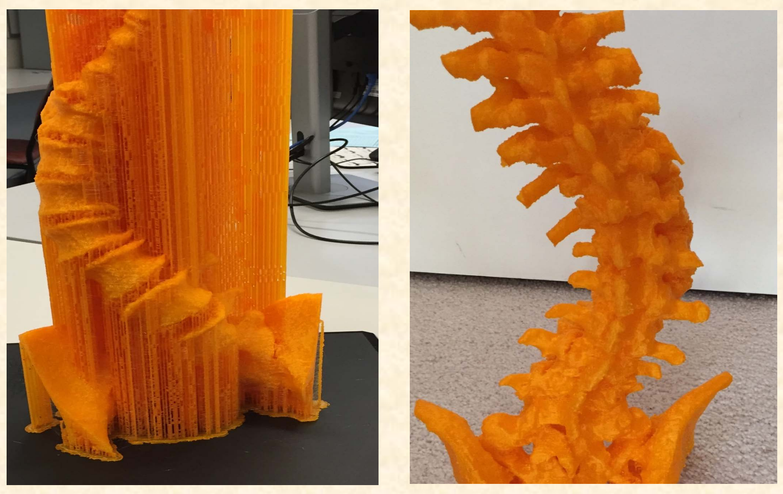
2008 Bone scan showed multilevel facet arthropathy and an extensive scoliosis concave to the left.



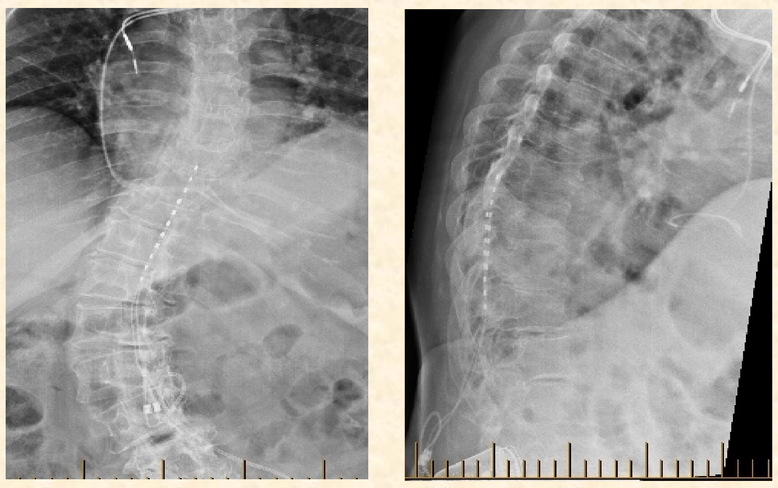
2014CT scan showed severe multilevel degenerative disc disease, marked curvature of the spine at the thoracolumbar junction and compensatory lumbar curvature. Extensive facet arthropathy and calcific arachnoiditis.



The 3D recontructions were hard to use, only allowed short and long axis rotation and as presented were not optimised for caudad –cephalad viewing.



The 3D model was slow to print but gave great detail and allowed unlimited long, short axis rotation and everything between.



AP and Lateral spine x-rays showing implanted stimulator leads

Results

The model took 72 hours to print and another 2-3 hours of technician time to prepare the model.

A good space was identified at T12/L1 and the model showed a right sided approach would give better access and thoracic spine lead placement.

Two temporary Nevro octrode leads were inserted from the right at T12/L1 with the tips positioned offset at right T9 and left T8. 2 weeks later after a successful trial a permanent system was implanted.

The system remains in site and continues to provide acceptable pain relief

Discussion

Standard practice involves using preoperative imaging alone to plan surgery. This approach allows for discussion and "mental imagery" – but technical difficulties can arise during the procedure that have not been anticipated. 3D CT reconstructions enhance this process, but do not allow the hands-on experience.

The 3D model allowed a "hands on" planning of the approach. It allowed a number of approaches to be "walked though" – and the best of the available options chosen for the actual procedure. Patient positioning and needle access approaches being pre-planned aided in a successful outcome (which had not been achieved before).

Conclusions

The 3D model took additional time to prepare however it proved to be more useful than the CT-scan 3D reconstruction and made a useful contribution to the successful implantation of the spinal cord stimulator.

This technology has potential application in planning difficult cases, making needle jigs and training.

Reprints

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