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Cannulated Pedicle Screw (CPS) Augmented by Polymethylmethacrylate (PMMA)

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Abstract:

When treating lumbar spondylolisthesis with osteoporosis, cannulated pedicle screw (CPS) enhanced by polymethylmethacrylate (PMMA) can achieve satisfactory clinical efficacy. Nonetheless, precise CPS application will lessen the likelihood of PMMA-related issues and help to prevent the challenge of screw revision.

Keywords: cannulated pedicle screw, polymethylmethacrylate, PMMA.

Introduction:

The most successful technique created to date is the cannulated pedicle screw (CPS) enhanced by polymethylmethacrylate (1). The main emphasis has been on optimizing the dosage of PMMA in surgery (3) and enhancing stability by modifying the screw's side hole design (2). Surgeons have, however, become more aware of PMMA-related issues that may occur in clinical settings, including PMMA leakage, allergic responses, venous or pulmonary embolism, and challenges with CPS revision (4).

Screw design:

The barrel-shaped bone cement-injectable cannulated pedicle screw (CICPS) from Kanghui Medical Devices Co., Ltd. in Jiangsu, China, has a 3-mm pitch and a range of outer diameter and length parameters (the screws utilized in this investigation were 6.5 mm in diameter and 45 mm in length) (Figure A). The pedicle screw's multi-axis or single-axis screw head is made to facilitate surgery, and its cannulation diameter is 2.2 mm. At the screw's distal end, three side holes are positioned from smallest to largest: round, 2 mm in diameter; oval, 3 mm long and 2 mm wide; and U-shaped, 4 mm long and 2 mm broad. The first 2/5 of the CPS tip was primarily intended for injection holes (Figure B).

Following the implantation of the CICPS, the PMMA is injected using a specially made syringe and adapter, and it spreads through the three side holes into the surrounding bone's trabeculae (Figures C and D). In order to efficiently inject the right amount of PMMA, the new syringe is made with small gradations. If intraoperative imaging reveals leakage, the PMMA injection can be stopped (5).

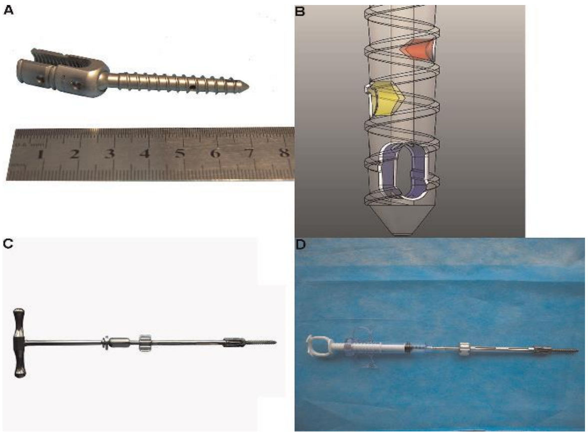

Figure 1: The CICPS. B: At the screw's distal end, three side holes were positioned in ascending order of size. C and D: An adapter is used to connect the CICPS to the T-shaped handle and the specifically made bone cement syringe **(5).**

The PMMA outflow channel design is the primary distinction between CICPS and other cannulated screws. PMMA distribution was assessed using cannulated screws with varying numbers of side holes (2). Almost no PMMA was seen in the distal holes, while a significant amount of PMMA flowed out of the proximal side holes that were arranged oppositely; 2) the closer the proximal side hole was to the screw head, the higher the axial force pulling it out and the higher the chance of cement leakage. These conclusions are supported by our findings. Based on the aforementioned findings, the central hollow tract was sealed at the screw tip and the three CICPS side holes were positioned two-fifths of the way from the distal end of the screw, in order of size. According to imaging studies, more cement flowed to the screw's distal end thanks to the CICPS design. Nearly little PMMA distribution was seen in the proximal half of the screw, whereas it was evenly dispersed across the distal half **(5).**

Surgical techniques

All patients undergoing posterior internal fixation had to be prone under general anesthesia. A posterior midline incision was used to access the lesion, and depending on the features of the lesion, a total laminectomy and posterolateral fusion were carried out. Following confirmation that the damaged nerve roots had fully decompressed, a tapper was used to tap the location of the transpedicular screw. To make sure there was no cortical bone rupture, a 3-mm needle was placed into the vertebrae via the pedicle screw tract that had been prepared. The screw insertion angle was made marginally larger than that of a traditional pedicle screw in order to give PMMA distribution a wider area (Figure A). Furthermore, the screw's length ought to be between 80% and 90% of the vertebra's length (Figure B).

The adapter was used to connect the pedicle screw to the specifically made syringe after the screw had been injected. For augmentation, 1 to 2 milliliters of PMMA were injected into each cannulated screw. The ideal injection timing occurs during the sticky stage, and 1.5 ml of PMMA is the ideal amount. X-ray imaging was used at every stage of the process to prevent cement leakage into the neural canal. PMMA injection was halted if a lateral X-ray view revealed cement leaking to the screw's posterior portion (5).

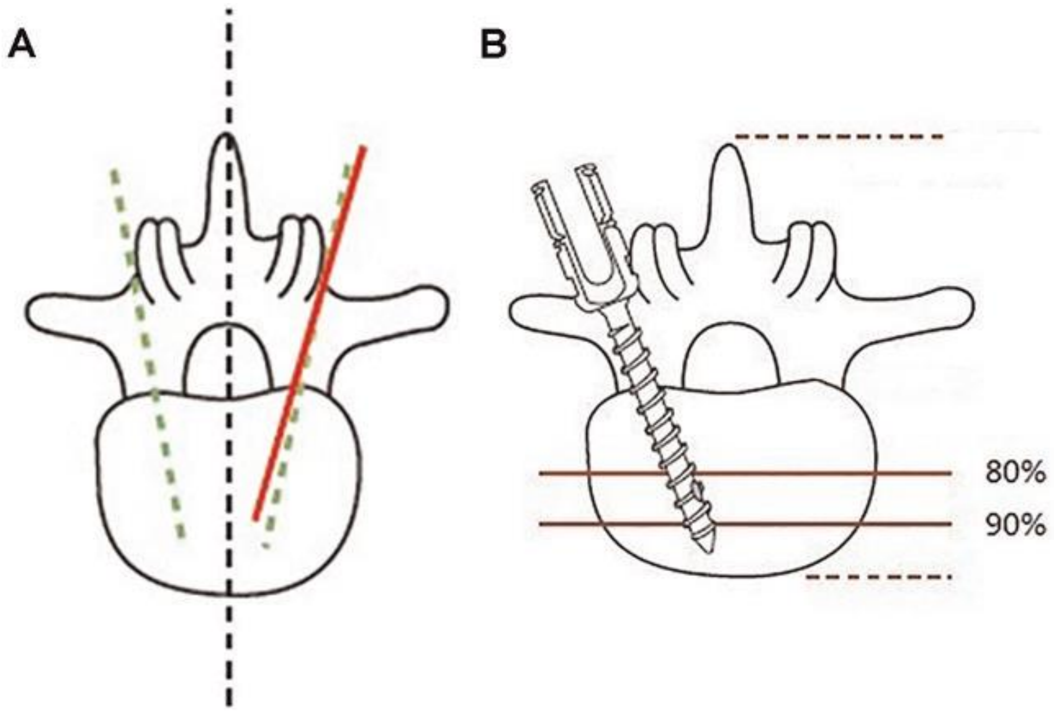

Figure 2: The screw insertion angle is made slightly larger than that of a conventional pedicle screw (shown with a solid red line). B: When determining the proper screw length, a circular side hole in the anterior 80% to 90% of the vertebral body is appropriate **(5).**

There is a correlation between the amount of CPSs implanted and the likelihood of CL, so reducing the application of non-essential CPSs during surgery is crucial to lower the CL rate (4).

Because of the tiny volume of the thoracic vertebrae, their close proximity to the thoracic cavity, and their small venous pressure, CPSs employed in the thoracic vertebra were a risk factor for CL, particularly S-type leaking (6).

When positive end-expiratory pressure (PEEP) breathing is increased after PMMA injection, intrathoracal structures such as the caval vein, right and left atrium, and ventricle are compressed. This, in turn, raises the pressure on the cement leak's backflow veins. As a result, increasing PEEP will lessen bone cement leakage. Although prolonged PEEP elevation can result in organ dysfunction due to reduced cardiac output, a PEEP of 15 cmH2O during cement injection during spine surgery appears to be straightforward, secure, and efficient. Because of its proximity to the thoracic cavity and increased susceptibility to intrathoracic pressure, the thoracic vertebra may be less prone to Type S leaking if PEEP is increased during cement injection. It is still unclear, though, if it might raise the rate of Type B and Type C leaks (7).

The far anterior lumbar vertebral vein from the thoracic cavity may be the cause of Type B leakage, however the lumbar vertebra is not a risk factor for Type S or Type C leaks. Because of the negative intrathoracic pressure and blood reflux during respiration, the intravenous pressure is particularly high, indicating a higher likelihood of Type B leakage. Bone cement readily enters the spinal canal through segmental veins in type B leaking situations. Despite this, the lumbar spinal canal is larger than the thoracic one. Type B leakage was less likely the closer the screw injection hole was to the screw tip (8). Thus, in lumbar surgery, choosing CPS with injection holes close to screw tips may lower the risk of Type B leakage (9).

Types of cement leakage: classified by Yeom typing **(10).**

Type S, through the prevertebral vein (Fig. a, Fig. d); Type B, through the segmental vein (Fig. b and e); Type C, leakage through cortical defect (Fig. c and f).

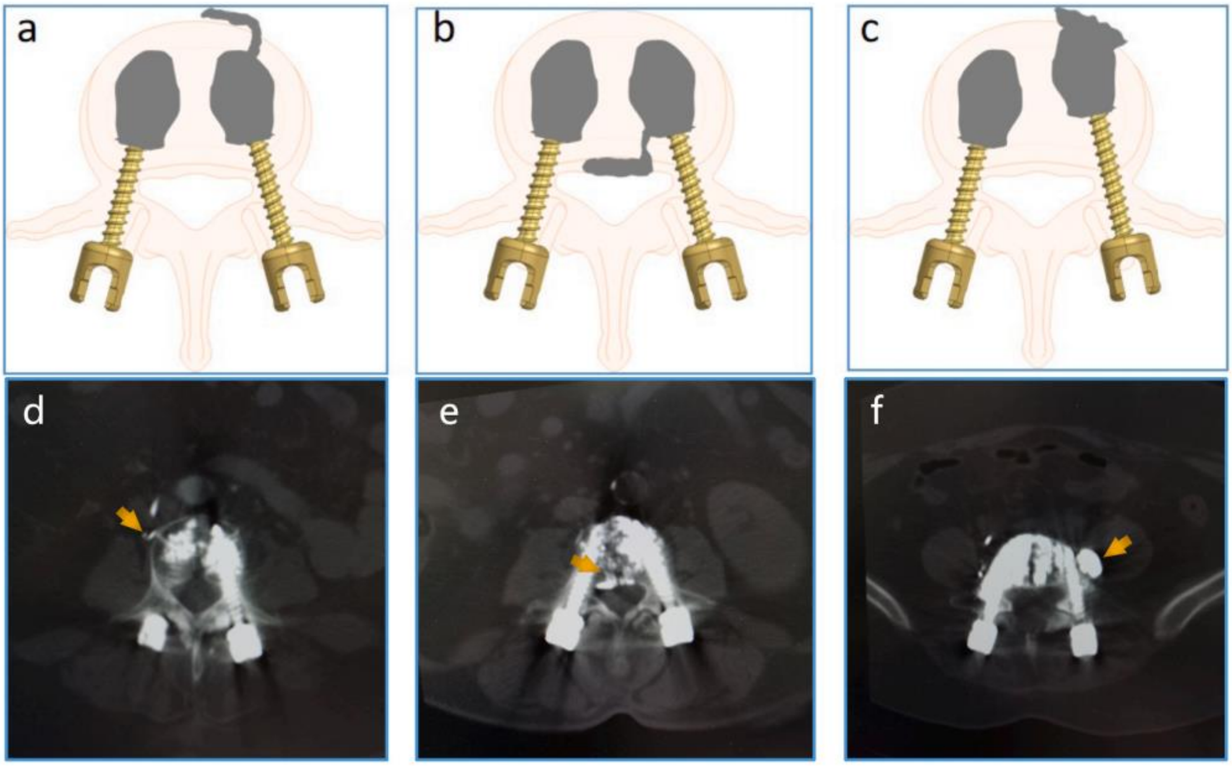

Figure 3: Typing of bone cement leakage. Type S, through the prevertebral vein (a, d); Type B, through the segmental vein (b, e); Type C, leakage through cortical defect (c, f) **(3).**

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