

Transfacetal Screw Fixation in Sub-Axial Cervical Spine with Rod Augmentation (New Technique)

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Abstract

Background: Anatomically cervical spine consists of the cervical vertebrae aligned with prominent cervical lordosis. Third, fourth, fifth and sixth cervical vertebrae present special features. Internal fixation of the cervical spine is frequent procedures carried-out via spine surgeons in variant settings like infection, trauma, neoplasm as well as congenital malformations. Transfacetal screw fixation in cervical spine was 1st described by Roy Camille et al., in 1972 in the setting of lateral mass fractures. Transfacetal screw fixation provide zero movement at the joint and provide quintessential situation for arthrodesis.

Aim of Study: Describe transfacetal screw fixation with using screws for lateral mass instead of facet screws with adding rod augmentation.

Material and Methods: Description of a new technique by augmentation of the transfacetal screw with rod insertion to the procedure on a cadaver in the Anatomy Department Morgue, Beni-Suef University December April 2024.

Results: In this method we use an entry point 2mm medial and caudal to the mid-point of the lateral mass with twenty degrees laterally and forty degrees caudally for insertion of the transfacetal screw with adding rod augmentation to the inserted screws.

Conclusion: Augmentation of the transfacetal screws might be done with any method with use of different type of screw.

Key Words: Transfacetal Screw – Fixation – Cervical Spine – Rod Augmentation.

Introduction

ANATOMICALLY cervical spine involves seven cervical vertebrae aligned with prominent cervical lordosis. Third, fourth, fifth and sixth cervical vertebrae present special characteristics [1].

The inferior and superior articular facets form the lateral mass or articular mass, anatomically the lateral mass lies anterolateral to the laminae [2].

Articular facets These are situated directly posterior to the transverse process and its foramen transversarium. There exist 2 superior processes and 2 inferior processes. Every process has a smooth surface referred to as an articular facet. The 2 superior facets will articulate with the 2 inferior facets of the 2 vertebra, developing the zygapophyseal (or facet) joints. They might be known as joints of the vertebral arch, as the processes develop on the lateral bony components of the arch. When the vertebrae are stacked one on top of the other, the vertebral arch, articular processes, and zygapophyseal joints of adjacent vertebrae, forms a passageway for spinal nerves referred to as the intervertebral foramen. The intervertebral foramen permits the exit of spinal nerves at every vertebral level from the vertebral canal. Finally, the almost horizontal orientation of the articular facets in the cervical spine is, in part, responsible for providing the cervical spine the greatest range and variety of motion [3].

Internal fixation of the cervical spine is a prevalent process conducted via spine surgeons in several settings, like infection, neoplasm, trauma, in addition congenital malformations [4,5].

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Transfacetal screw fixation in cervical spine was ^{1st} described by Roy Camille et al. [6] in the setting of lateral mass fractures [6]. Transfacetal screw fixation provide zero movement at the joint and provide quintessential situation for arthrodesis. Transfacetal screw fixation is indicated in cases of degenerative cervical diseases in addition to traumatic cases but the facet must be intact. Transfacetal screw fixation in sub axial cervical spine described by many authors.

Takayasu technique described an entry point on vertical line bisecting the lateral mass, at the mid-way caudal ^{3rd} of the lateral mass with zero lateral angulation and 60 to 80° caudal angulation [8]. Dal Canto technique [9] described an entry point 2mm caudal to the midpoint of the lateral mass with 20° lateral angulation and 40-degree caudal angulation.

Kelkamp technique [10] described an entry point 1mm medial and on to two millimeters caudal to the midpoint of the lateral mass with 20° lateral angulation and 40° caudal angulation.

Miyanji technique [11] described an entry point at the mid-point of the lateral mass with neutral to 5° lateral angulation and perpendicular to facet joint. Describe transfacetal screw fixation with using screws for lateral mass instead of facet screws with adding rod augmentation.

Material and Methods

A new technique for augmenting transfacetal screw fixation with rod insertion was developed and tested on a cadaveric cervical spine specimen. The procedure was conducted in the Anatomy Department Morgue, Beni-Suef University, during the period from December 2024 to April 2024. This research aimed to explore the feasibility and biomechanical advantages of using transfacetal screw fixation in the sub-axial cervical spine with rod augmentation.

Operative technique:

The procedure began with a midline skin incision over the posterior cervical spine. The incision was extended along the expected exposure zones from C2 to C7, based on the anatomical landmarks and the desired vertebral levels for screw placement. Once the incision was made, the paraspinal musculature has been carefully dissected from the midline to the lateral edges. Self-retaining retractors have been situated to maintain proper exposure of the cervical spine, allowing for clear visualization of the facet joints and lateral masses from C3 to C7.

The borders of the lateral mass were then identified and meticulously defined. These included the medial, lateral, superior, and inferior borders, which are essential for the accurate placement of the transfacetal screws. At this stage, a laminectomy was performed from C3 to C7 to provide optimal exposure for the fixation procedure. The laminectomy also helped decompress the neural elements and create additional space for screw placement and rod insertion.

Once proper exposure was achieved, the procedure proceeded with the placement of the entry points for the screws. A two millimeters drill was utilized to create a precise entry point, which has been located 2 millimeters medial and 2 millimeters caudal to the midpoint of the lateral mass. This careful location of the entry point was crucial to ensuring that the screws would be directed through the facet joint without violating adjacent anatomical structures. After creating the initial entry point, a tap was inserted and advanced perpendicular to the bone for a few millimeters to prepare the trajectory for screw insertion.

Subsequently, the tapping was directed at an angle of 20° laterally and 40° caudally, ensuring that the screw path was properly aligned with the facet joint and lateral mass. The tap was advanced carefully to sustain the integrity of the facet joint, avoiding any anterior penetration into the vertebral body. The accuracy of the trajectory was checked by probing the track with a feeler probe to ensure that there was no inadvertent anterior violation.

After confirming the proper trajectory, a lateral mass screw with a diameter of 3.5 millimeters and a length of 12 millimeters has been selected. The screw has been inserted into the prepared track. Initially, the screw was inserted perpendicular to the bone for several millimeters to avoid joint violation. Once the screw had penetrated sufficiently, it was directed caudally at a 40° angle and laterally at 20°. This angulation allowed the screw to engage the facet joint securely while avoiding damage to the adjacent structures. This process was repeated for the remaining levels of the cervical spine.

The procedure has been carried out bilaterally at the C2-3, C3-4, and C4-5 levels on the right side of the cadaver, and at the C3-4 and C4-5 levels on the left side. The decision to limit screw placement on the left side was due to pre-existing fractures at other vertebral levels in the cadaveric specimen, which prevented the insertion of screws at higher cervical levels. After the screws were placed, the rods were inserted bilaterally to connect the screws at the desired levels. The rods provided addition-

al mechanical stability and served to reinforce the construct, improving the overall rigidity of the fixation.

Once the screws and rods were in place, they were tightened and locked securely. The construct was visually inspected for stability, and no evidence of screw loosening or rod misalignment was

observed. This method was evaluated for its technical feasibility, safety, and biomechanical stability during the procedure.

Evaluation:

Postoperative CT cervical spine to evaluate that technique with rod augmentation.



(A)



(B)

Fig. (1): Postoperative sagittal CT cervical spine showing screws with rod augmentation.



Fig. (2): Postoperative axial CT cervical spine.

Results

The technique was successfully demonstrated on a cadaveric cervical spine specimen. Transfacetral screw fixation was achieved using an entry point located approximately 2 millimeters medial and caudal to the midpoint of the lateral mass. The screws were inserted at an angulation of 20° in the

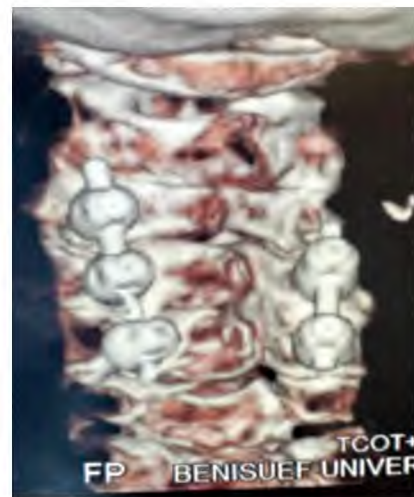


Fig. (3): Postoperative 3D CT cervical spine showing screws and rod.

lateral direction and 40° in the caudal direction. This trajectory allowed for secure passage through the facet joint, engaging both articular surfaces and providing firm anchorage within the posterior elements of the sub-axial cervical vertebrae.

After screw placement, rod augmentation was performed by connecting the screws on each side

with longitudinal rods. The rod construct was fixed in place using locking screw caps, ensuring rigidity across the involved motion segments. The rod augmentation added an extra layer of mechanical support to the transfacetal screw construct, providing increased resistance to flexion, extension, and rotational forces.

During the procedure, the technique proved reproducible with consistent anatomic landmarks guiding screw trajectory. The augmented construct was visually assessed for stability, and no evidence of cortical breach or loosening was observed on gross examination. The addition of the rod not only enhanced the rigidity of the construct but also helped in distributing the mechanical loads more evenly across the fixation points.

This modified transfacetal technique, utilizing lateral mass-type screws with rod augmentation, demonstrated technical feasibility and potential biomechanical benefits. The augmentation addressed one of the recognized limitations of standalone transfacetal screws namely, their relatively lower strength compared to other cervical fixation methods. The enhanced construct could be particularly useful in cases where lateral mass or pedicle fixation is contraindicated or where additional reinforcement is clinically desired.

However, several drawbacks were noted. First, transfacetal screw fixation inherently offers less biomechanical strength compared to pedicle screw fixation, particularly in cases involving poor bone quality or significant vertebral deformity. While rod augmentation improved overall construct stability, it adds complexity to the procedure and may increase operative time. Second, the altered screw trajectory may pose a risk to adjacent facet joint cartilage and could theoretically increase the likelihood of postoperative facet joint degeneration. Third, since this method relies heavily on precise angulation and anatomical familiarity, there may be a steeper learning curve for surgeons not accustomed to this trajectory, particularly in the absence of intraoperative imaging guidance. Lastly, the utilize of lateral mass-type screws in a transfacetal path is a modification from traditional technique, and while feasible, the long-term biomechanical behavior of such a construct remains to be validated in clinical and laboratory settings.

Despite these limitations, the augmented transfacetal construct shows promise as a viable alternative for posterior cervical spine stabilization, especially in cases where other fixation options are unsuitable.

Discussion

Posterior cervical spine fixation techniques have evolved significantly over the previous decades, with lateral mass screws and cervical pedicle screws being the most frequently applied constructs. Lateral mass fixation, introduced by Roy-Camille [6] and refined by Magerl and Anderson [12], remains widely accepted due to its ease of application and acceptable safety profile [11]. However, its biomechanical limitations in providing rigid fixation, especially in multilevel or osteoporotic cases, have driven the pursuit of alternative techniques. Pedicle screw fixation offers superior biomechanical stability nevertheless is technically demanding and carries increased risk of neurovascular injury due to the narrow pedicle diameter and proximity to critical structures like the spinal cord and vertebral artery.

Transfacetal screw fixation, ^{1st} described by Roy-Camille [6], offers a middle ground between these two techniques. By crossing the facet joint, this approach achieves solid bony purchase through the articular processes, promoting fusion through direct joint immobilization [13]. However, traditional transfacetal screw fixation has been criticized for offering limited stability when used alone, especially in multisegment constructs or cases with high mechanical demand [14].

Regarding transfacetal screw fixation Takayasu technique [8], Dal Canto technique [9], Kelkamp technique [10], and Miyanji technique [11] used different entry points and angulations without rod augmentation.

In our study, we introduced and evaluated a modified technique of transfacetal screw fixation with rod augmentation, using screws typically designed for lateral mass fixation. The addition of rods significantly reinforced the construct, distributing loads across multiple segments and enhancing resistance to motion in all planes. This approach seeks to combine the technical simplicity and safety of transfacetal screw placement with the improved mechanical integrity provided by rod constructs, as seen in standard lateral mass or pedicle screw-rod systems [15].

When in comparison with lateral mass fixation, the augmented transfacetal construct provides a potentially more rigid fixation by directly immobilizing the facet joint, the primary source of motion in the posterior column. Furthermore, it preserves the surrounding anatomical corridors, reducing the possibility of injuring the vertebral artery, which may be encountered during pedicle screw place-

ment [12]. Additionally, the technique may be especially advantageous in patients with anatomical variations or deformities where standard landmarks for lateral mass or pedicle screws are not clearly identifiable [16].

Despite these advantages, the technique is not without drawbacks. Compared to pedicle screws, the biomechanical strength of transfacet screws – even when augmented with rods – may still be inferior, particularly in cases with compromised bone quality. Furthermore, direct violation of the facet joint raises concerns regarding potential post-operative facet degeneration and joint-related pain, though this may be mitigated by achieving successful arthrodesis. Lastly, while the trajectory for transfacet screws is technically straightforward, precise angulation is required to avoid breaching adjacent structures, necessitating familiarity with cervical anatomy and, ideally, fluoroscopic or navigational assistance.

Overall, the proposed technique offers a promising alternative for posterior cervical stabilization, particularly in resource-limited settings or when traditional fixation methods are not viable. Further biomechanical testing and clinical researches will be necessary to validate the long-term efficacy and safety of this modified approach.

Conclusion:

The modified transfacet screw fixation technique with rod augmentation in the sub-axial cervical spine demonstrates technical feasibility and potential biomechanical advantages. By utilizing a familiar screw type and enhancing construct stability through rod connection, this method offers a viable alternative to traditional lateral mass and pedicle screw systems, particularly in cases where anatomical limitations, surgical experience, or resource constraints may restrict the use of more complex fixation methods.

Although this cadaveric study showed promising stability and reproducibility, certain drawbacks such as facet joint violation and potentially lower strength compared to pedicle constructs must be considered. Further biomechanical testing and clinical studies are essential to validate the safety, fusion rates, and long-term outcomes of this technique in real-world patient populations.

In conclusion, this new approach expands the surgical options for posterior cervical fixation and may provide a valuable tool in the armamentarium of spine surgeons, especially in challenging clinical scenarios.

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تثبيت مفصل الفقرات العنقية واستخدام دعائم: تقنية جديدة

تناولت هذه الدراسة وصف لتقنية جديدة لتثبيت الفقرات العنقية وتدعيمها بشريحة عنقية، وقد أجريت هذه الدراسة من قبل، بعدة طرق ولكن بدون استخدام القضييب العنقى، في هذه الدراسة يتم استخدام مسمار وقضييب عنقى على الجانبين، والتقنية هى تحديد نقطة منتصف الكتلة الجانبية للفقرات العنقية ونبدأ ب ٢ مللى أسفل و ٢ مللى داخل نقطة المنتصف، ويكون اتجاه المسمار ٠٤ درجة للأسفل و ٢٤ درجة خارجى، وتحتاج هذه الدراسة لمزيد من البحث لتقييمها كوسيلة لتثبيت الفقرات العنقية.