

ZERO-PROFILE ANCHORED SPACER VERSUS PEEK CAGE WITH ANTERIOR PLATING FOR SINGLE-LEVEL TRAUMATIC CERVICAL SPINE INJURY

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ABSTRACT

Background: Anterior cervical discectomy and fusion is used to decompress and stabilize selected traumatic subaxial cervical injuries. A conventional polyetheretherketone cage with an anterior plate provides rigid fixation, but the plate may contribute to postoperative dysphagia. Zero-profile anchored spacers avoid a separate anterior plate. **Objective:** To compare fusion, postoperative dysphagia, neurological status, hospital stay, and pain after single-level anterior cervical discectomy and fusion with a zero-profile anchored spacer or a PEEK cage with anterior plating. **Methods:** This single-centre quasi-experimental study enrolled 46 patients with traumatic single-level C3-C7 injury by consecutive sampling. Twenty-three patients received a zero-profile anchored spacer (Group A), and 23 received a PEEK cage with anterior plating (Group B). Neurological status was graded with the American Spinal Injury Association Impairment Scale, dysphagia with the Bazaz system, pain with a 0-10 visual analogue scale, and fusion by postoperative imaging. Between-group comparisons used independent-samples t tests, Pearson chi-square tests, or two-sided Fisher exact tests, as appropriate; effect estimates are reported with 95% confidence intervals. **Results:** Fusion occurred in 21/23 patients (91.30%) in Group A and 20/23 (86.96%) in Group B (two-sided Fisher exact $p=1.000$). Dysphagia occurred in 2/23 (8.70%) and 3/23 (13.04%), respectively ($p=1.000$). At discharge, ASIA grade distributions did not differ (Pearson chi-square $p=0.348$). Mean hospital stay was 25.18 $\pm$ 6.04 days in Group A and 28.74 $\pm$ 2.99 days in Group B, a reduction of 3.56 days (95% CI 0.73-6.39; $p=0.015$; Hedges $g=0.73$). VAS scores at six months were 2.00 $\pm$ 0.00 and 2.13 $\pm$ 0.34 ($p=0.073$). **Conclusion:** The zero-profile anchored spacer significantly reduced hospital stay while achieving a high fusion rate, a lower observed frequency of dysphagia, and favourable neurological and pain outcomes. These findings support the zero-profile construct as an effective alternative to plate-cage fixation, although the small nonrandomized sample limits claims of overall superiority.

Keywords:

Anterior cervical discectomy and fusion; traumatic cervical spine injury; zero-profile anchored spacer; PEEK cage; anterior cervical plate; dysphagia; fusion

INTRODUCTION

Traumatic subaxial cervical spine injury can produce disc disruption, instability, spinal cord compression, and progressive neurological loss. When anterior compression and single-level instability predominate, anterior cervical discectomy and fusion (ACDF) permits direct decompression and reconstruction of the anterior column. The procedure requires an interbody construct that maintains disc height and alignment while fusion develops (Aebi, 2009; Kim et al., 2018).

A PEEK cage combined with an anterior plate is a familiar construct. PEEK is radiolucent and has an elastic modulus closer to bone than metallic implants, while the plate adds immediate resistance to graft displacement and segmental motion (Kurtz and Devine, 2007; Toth et al., 2006). The plate also occupies the prevertebral space. Its profile, retraction during insertion, and local soft-tissue response have been linked to dysphagia after anterior cervical surgery (Bazaz et al., 2002; Lee et al., 2005; Shriver et al., 2017).

Zero-profile devices combine an interbody spacer with integrated screws or anchoring clips and do not require a separate plate. Biomechanical studies have reported segmental stability compatible with fusion, and comparative studies in degenerative disease generally report similar fusion with less dysphagia than cage-plate constructs (Scholz et al., 2011; Scholz et al., 2015; Sun et al., 2018; Yin et al., 2016). Evidence in trauma is thinner. Kim et al. (2018) reported acceptable radiological outcomes in traumatic subaxial disc injury, and Song et al. (2023) found similar fusion with less dysphagia, blood loss, and operating time for ROI-C than for a plate-cage construct in traumatic central cord syndrome.

We compared a zero-profile anchored spacer with a PEEK cage and anterior plate in patients undergoing single-level ACDF for traumatic C3-C7 injury. Our primary outcomes were fusion and postoperative dysphagia; neurological recovery, hospital stay, and pain were secondary outcomes.

Rationale

A separate anterior plate may improve immediate construct rigidity, but it adds operative steps and occupies the tissue plane adjacent to the oesophagus. A zero-profile anchored spacer may reduce plate-related swallowing symptoms while preserving segmental fixation. Most comparative evidence concerns degenerative cervical disease, and results from that population may not transfer directly to acute traumatic instability. A direct comparison in traumatic single-level injury was therefore warranted.

Literature Review

Postoperative dysphagia is one of the most frequently studied adverse outcomes after anterior cervical surgery. Reported rates vary with follow-up time, surgical levels, plate characteristics, and the instrument used to identify swallowing difficulty. Bazaz et al. (2002) introduced a symptom-based grading system that separates none, mild, moderate, and severe dysphagia according to frequency and the type of food affected. A later meta-analysis estimated an overall dysphagia rate of 8.5% after plated ACDF, while also showing substantial variation among studies (Shriver et al., 2017).

Zero-profile constructs were developed to reduce anterior prominence while retaining interbody fixation. Clinical and biomechanical reports indicate that these devices can provide adequate segmental stability, although design differences between integrated screws and anchoring clips matter (Scholz et al., 2011; Scholz et al., 2015; Lee et al., 2015). Meta-analyses of mainly degenerative cases report lower dysphagia with zero-profile devices and similar fusion, but these pooled findings do not remove concerns about subsidence, sagittal alignment, or device-specific failure (Sun et al., 2018; Yin et al., 2016; Zhang et al., 2022).

Trauma-specific evidence remains limited. Kim et al. (2018) described 12 patients with traumatic subaxial disc injury treated using Zero-P and reported fusion without sagittal malalignment. Song et al. (2023) compared 20 ROI-C cases with

17 plate-cage cases in traumatic central cord syndrome. Fusion occurred in all patients; dysphagia at discharge occurred in 10.0% and 47.1%, respectively, and resolved within three weeks. Although injury definitions and device designs differ, these data provided the dysphagia proportions used in our sample-size calculation.

Hypotheses

The null hypothesis was that fusion and postoperative dysphagia would not differ between the zero-profile and plate-cage groups. The alternative hypothesis was that at least one of these outcomes would differ between groups. Because the study was powered from an expected dysphagia difference and did not specify a non-inferiority margin, failure to reject the null hypothesis cannot be interpreted as proof of equivalence.

Objectives

The primary objective was to compare fusion and postoperative dysphagia between the two constructs. Secondary objectives were to compare discharge neurological status, hospital stay, and VAS pain scores through six months.

Materials And Methods

Study design and setting. We conducted a 12-month quasi-experimental comparative study in Neurosurgery Unit II, Punjab Institute of Neurosciences, Lahore General Hospital, Lahore. Institutional ethical approval was obtained, and every participant provided written informed consent before enrolment.

Participants and sample size. We enrolled 46 patients by non-probability consecutive sampling and allocated 23 to each procedure. OpenEpi yielded a sample of 23 per group at 80% power and a 5% significance level, based on dysphagia proportions of 10.0% for a zero-profile device and 47.1% for a plate-cage construct reported by Song et al. (2023). Eligible patients had radiologically confirmed traumatic single-level C3-C7 injury requiring ACDF, including subluxation without locked facets. We excluded non-traumatic or degenerative disease, previous surgery at the same level, pregnancy, cardiac disease, systemic infection or impaired bone healing, pre-existing swallowing

disorders, ASA class IV or higher, uncontrolled hypertension or diabetes, polytrauma, and BMI at least 36 kg/m².

Interventions. Group A underwent a Smith-Robinson anterior approach, discectomy and endplate preparation, followed by insertion of a PEEK Prevail zero-profile anchored spacer (Medtronic, USA) filled with calcium-phosphate bone substitute. The device was fixed to the adjacent vertebral bodies without a separate anterior plate. Group B underwent the same exposure and decompression, followed by a Solis PEEK cage (Stryker Spine, USA) packed with demineralized bone matrix and local bone, plus a Zephir anterior cervical plate secured with unicortical screws. Implant position and alignment were checked fluoroscopically. A cervical orthosis was advised for two weeks, and early mobilization was encouraged.

Outcome assessment. We recorded neurological impairment with the ASIA Impairment Scale at admission and discharge. Dysphagia was graded with the Bazaz system during admission and at 2 weeks, 6 weeks, and 3 months. Pain was measured on a 0-10 VAS before surgery, immediately after surgery, and at 3 and 6 months. A consultant radiologist assessed fusion at 3 and 6 months using CT evidence of bridging bone and radiographic motion criteria adapted from Oshina et al. (2018).

Statistical analysis. Continuous variables are presented as mean $\pm$ standard deviation and categorical variables as number and percentage. We used independent-samples t tests for continuous outcomes, Pearson chi-square tests for multi-category ASIA distributions, and two-sided Fisher exact tests for sparse 2 x 2 tables. We calculated mean differences, risk differences, risk ratios, Hedges g, and 95% confidence intervals to show the magnitude and precision of between-group effects. Statistical significance was set at $p < 0.05$.

Table 1. Baseline characteristics

Characteristic	Group A Zero-profile (n=23)	Group B Plate-cage (n=23)	p valu e
Age, years	52.35 +/- 10.71	49.35 +/- 9.60	0.32 3
Male sex	14 (60.87%)	13 (56.52%)	0.76 5
Comorbidity present	1 (4.35%)	2 (8.70%)	1.00 0*
Admission ASIA A/B/C/D	2/4/11/6	2/2/11/8	0.81 3

Values are mean +/- SD or n (%). *Two-sided Fisher exact test; other p values use Pearson chi-square or independent-samples t tests.

Results

Patient characteristics. The study included 46 patients, 23 per group. Mean age was 52.35 +/- 10.71 years in Group A and 49.35 +/- 9.60 years in Group B (p=0.323). Twenty-seven participants were male. Admission ASIA distributions were similar (p=0.813). The overall age distribution was 6/46 (13.04%) aged 20-40 years, 11/46 (23.91%) aged 41-50 years, and 29/46 (63.04%) aged 51-68 years.

Primary outcomes. Fusion occurred in 21 patients (91.30%) in the zero-profile group and 20 (86.96%) in the plate-cage group, an absolute difference of 4.35 percentage points in favour of the zero-profile construct (RR 1.05, 95% CI 0.86-1.29; p=1.000). Dysphagia occurred in two patients (8.70%) and three patients (13.04%), respectively. This corresponded to a 33.3% lower observed relative risk with the zero-profile construct (RR 0.67, 95% CI 0.12-3.62), although the confidence interval was wide and the comparison was not significant (p=1.000).

Neurological status. Ten patients (43.48%) in the zero-profile group reached ASIA grade E at discharge compared with four (17.39%) in the plate-cage group. The absolute difference was 26.09 percentage points and the grade-E proportion was 2.50 times higher with the zero-profile construct (95% CI 0.91-6.83). This

favourable descriptive difference did not translate into a significant difference across the complete ASIA distribution (p=0.348).

Hospital stay. Mean stay was 25.18 +/- 6.04 days in the zero-profile group and 28.74 +/- 2.99 days in the plate-cage group. The zero-profile construct was associated with a 3.56-day reduction (95% CI 0.73-6.39; p=0.015), equivalent to 12.4% fewer hospital days relative to the plate-cage mean. The standardized difference was moderate to large (Hedges g=0.73).

Pain. VAS scores fell from 8.39 to 2.00 in the zero-profile group and from 8.26 to 2.13 in the plate-cage group by six months, corresponding to reductions of 76.2% and 74.2%. At six months, the between-group mean difference was -0.13 points (95% CI -0.27 to 0.01; p=0.073; Hedges g=-0.53), favouring the zero-profile construct, but it did not reach statistical significance.

Table 2. Clinical and radiological outcomes

Outcome	Group A Zero-profile	Group B Plate-cage	P value
Fusion	21 (91.30%)	20 (86.96%)	1.00 0*
Postoperative dysphagia	2 (8.70%)	3 (13.04%)	1.00 0*
Hospital stay, days	25.18 +/- 6.04	28.74 +/- 2.99	0.01 5
Discharge ASIA A/B/C/D/E	2/2/6/3/10	2/2/8/7/4	0.34 8

Values are n (%) or mean +/- SD. *Two-sided Fisher exact test. The complete ASIA distribution was compared with Pearson chi-square.

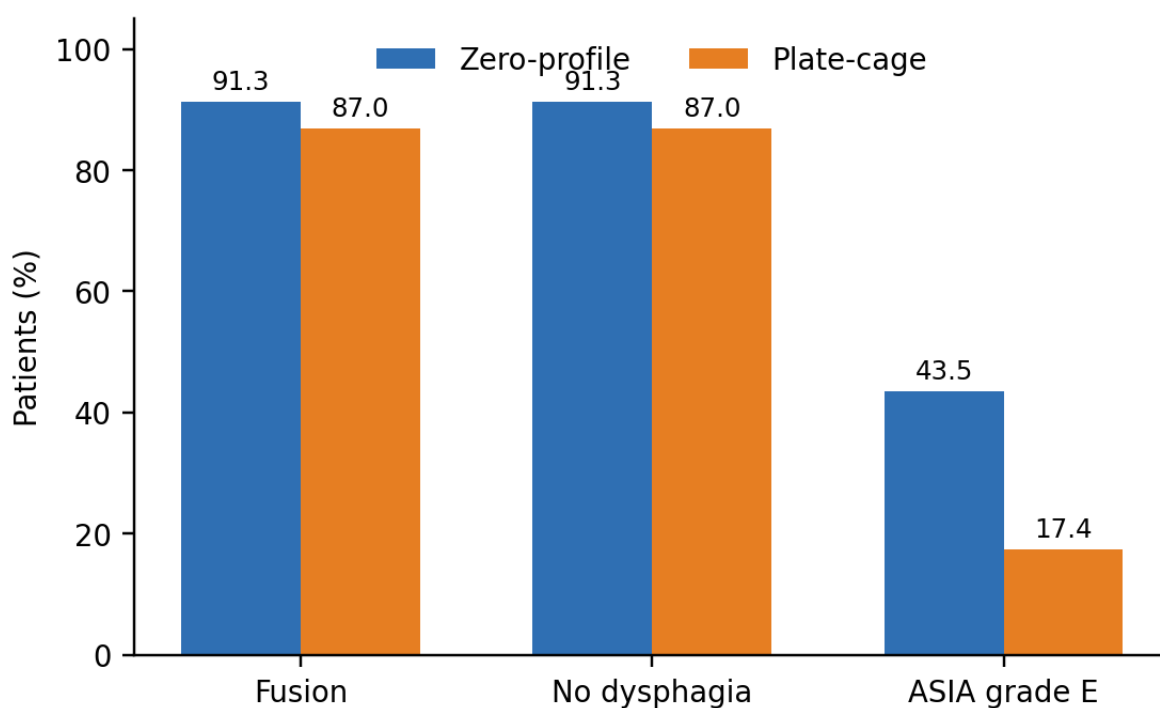


Figure 1. Favourable clinical outcomes by treatment group.

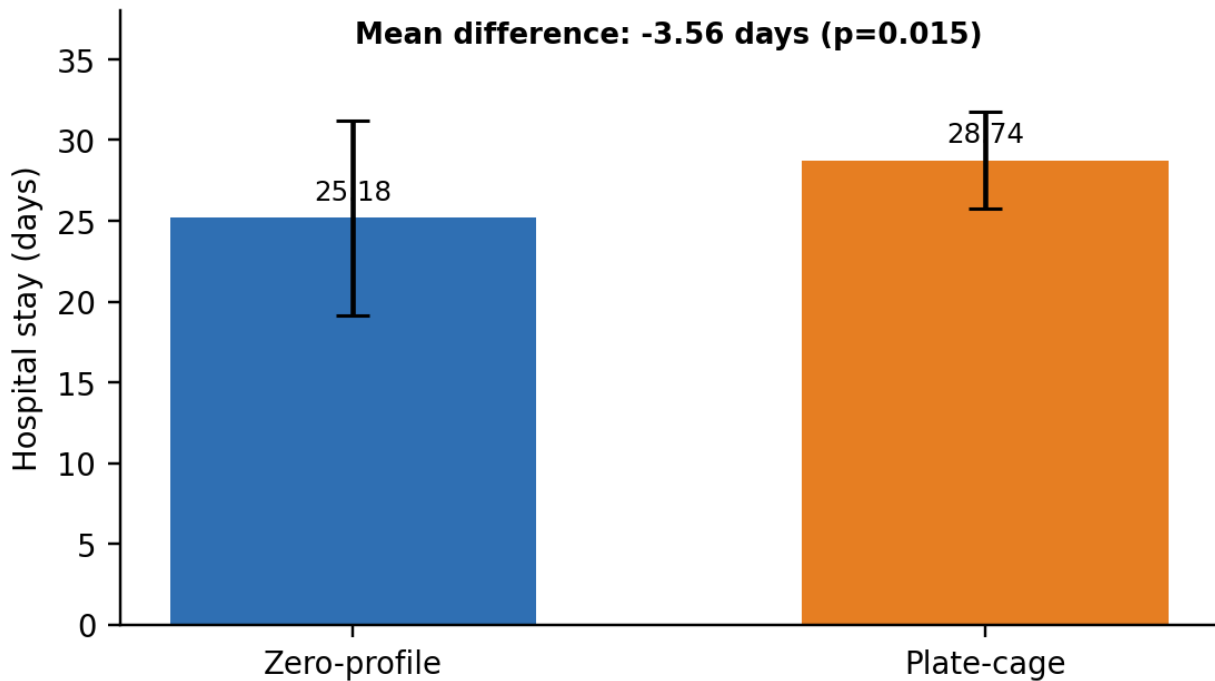


Figure 2. Mean hospital stay. Error bars show standard deviations.

Table 3. Visual analogue scale pain scores

Assessment	Group A Zero-profile	Group B Plate-cage	p value
Preoperative	8.39 +/- 0.50	8.26 +/- 0.45	0.359
Immediate postoperative	3.35 +/- 0.77	3.65 +/- 0.65	0.160
3 months	2.26 +/- 0.45	2.48 +/- 0.51	0.128
6 months	2.00 +/- 0.00	2.13 +/- 0.34	0.073

Values are mean +/- SD. P values are from pooled independent-samples t tests.

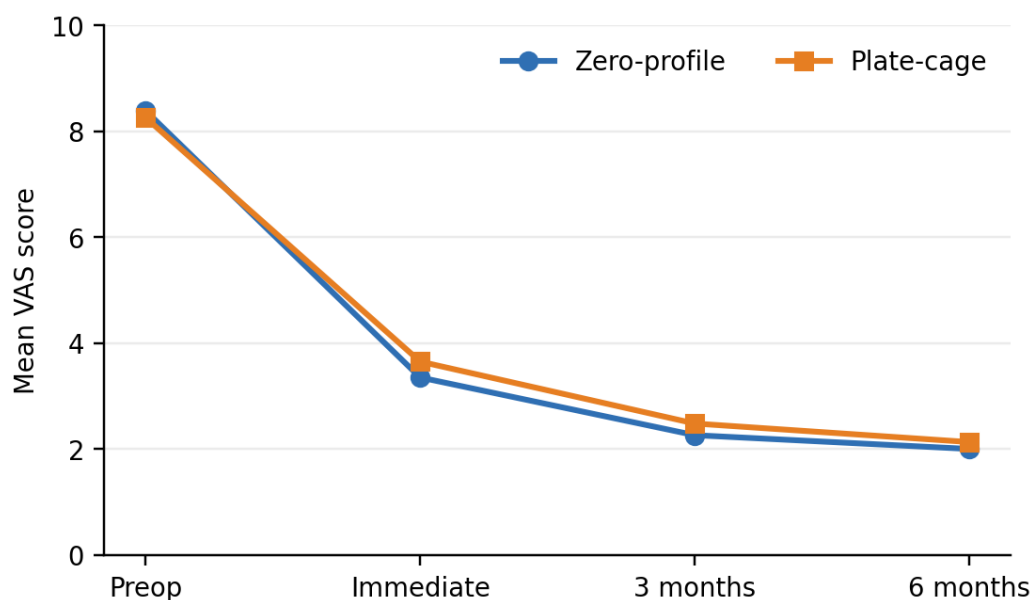


Figure 3. Mean VAS pain scores over follow-up.

Table 4. Magnitude of effects favouring the zero-profile construct

Outcome	Effect estimate (95% CI)	Observed advantage	Inference
Hospital stay	MD -3.56 days (-6.39 to -0.73)	12.4% shorter; Hedges $g = -0.73$	Significant, $p = 0.015$
Discharge ASIA E	RR 2.50 (0.91 to 6.83)	+26.09 percentage points	Favourable; uncertain
Fusion	RR 1.05 (0.86 to 1.29)	+4.35 percentage points	Favourable; uncertain
Freedom from dysphagia	RR 1.05 (0.86 to 1.29)	+4.35 percentage points	Favourable; uncertain
Six-month VAS	MD -0.13 (-0.27 to 0.01)	Lower pain; Hedges $g = -0.53$	Favourable; $p = 0.073$

Negative mean differences favour the zero-profile group for hospital stay and pain. CIs: confidence intervals; MD: mean difference; RR: risk ratio. Effect estimates are unadjusted.

Discussion

Our findings show a consistent direction of benefit for the zero-profile construct. It achieved a 4.35-percentage-point higher fusion rate, a 4.35-point higher freedom-from-dysphagia rate, a 26.09-point higher proportion of patients reaching ASIA grade E at discharge, and a 3.56-day shorter hospital stay. The hospital-stay difference was statistically significant and had a moderate-to-large standardized effect. The remaining estimates favoured the zero-profile construct but were imprecise because of the small number of patients and events.

The direction of the dysphagia result is consistent with the proposed benefit of avoiding a separate anterior plate, but the present estimate is imprecise. Song et al. (2023) reported dysphagia at discharge in 10.0% of ROI-C patients and 47.1% of plate-cage patients, with resolution within three weeks. Meta-analyses dominated by degenerative indications also found less dysphagia with zero-profile constructs while showing broadly similar fusion (Sun et al., 2018; Yin et al., 2016; Zhang et al., 2022). The current difference of one event between groups cannot confirm that effect. Dysphagia after ACDF varies with the definition and the timing of assessment, which makes an explicitly timed Bazaz grade important (Bazaz et al., 2002; Shriver et al., 2017).

Fusion exceeded 85% in both groups, supporting the ability of integrated zero-profile fixation to maintain a fusion environment without anterior plate prominence (Scholz et al., 2011; Lee et al., 2015). The 91.30% fusion rate in our zero-profile group was 4.35 points higher than the plate-cage rate, but the confidence interval included both benefit and harm. Fusion estimates also depend on imaging method; explicit motion and bridging-bone criteria therefore remain important (Oshina et al., 2018).

The 12.4% reduction in hospital days was the clearest between-group benefit. A shorter stay may reduce bed utilization and treatment burden, but length of stay after traumatic spinal injury can also reflect injury severity, medical complications, rehabilitation access, and discharge logistics. Because treatment was not randomized and these factors were not adjusted, the result should be

interpreted as an association rather than a causal effect.

This study has several limitations. It was conducted in one unit, included 46 patients, and used nonrandom treatment allocation. Baseline injury morphology, operative level, time to surgery, surgeon, blood loss, and operating time were not included in adjusted analyses. The small numbers of fusion failure and dysphagia events produced wide confidence intervals. Larger prospective multicentre studies with standardized follow-up and covariate-adjusted analyses are needed to determine whether the favourable estimates represent true clinical superiority.

Conclusion

In patients undergoing single-level ACDF for traumatic cervical injury, the zero-profile anchored spacer reduced hospital stay by 3.56 days while maintaining a high fusion rate and favourable dysphagia, neurological, and pain outcomes. Fusion was numerically higher, dysphagia was lower, and a greater proportion reached ASIA grade E than with plate-cage fixation. These results support the zero-profile spacer as an effective and potentially advantageous alternative, while the sample size and nonrandomized design prevent a definitive claim of overall superiority.

Declarations

Ethical approval and consent to participate: Institutional ethical approval was obtained, and written informed consent was secured from all participants.

Consent for publication: No identifiable patient material is included in this manuscript.

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Conflicts of interest: The authors declare that they have no financial or non-financial conflicts of interest that could have influenced the conduct, analysis, interpretation, or reporting of this study.

Data availability: De-identified data may be available from the corresponding author subject to institutional approval.

Author contributions: Muhammad Farhan Ejaz: Conceptualization, methodology, investigation, data collection, formal analysis, visualization, and writing of the original manuscript. Gohar Ali: Methodology, clinical investigation, validation, interpretation of findings, and critical revision of the manuscript. Muhammad Anwar Chaudhary: Supervision, resources, project administration, clinical guidance, and critical review of the manuscript. Abdul Majid: Supervision, validation, clinical interpretation, and critical review and editing of the manuscript. All authors reviewed and approved the final version of the manuscript.

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