Original Article

Unstable Hangman's fracture: Anterior or posterior surgery?

ABSTRACT

Context: Literature evaluating the efficacy and long-term clinico-radiological outcomes of anterior cervical discectomy and fusion (ACDF) and posterior fixation at C2–C3 for the treatment of unstable hangman's fractures is scanty.

Aims: The aim of this study is to compare the efficacy, clinical-radiological outcomes, and complications of ACDF and posterior fixation techniques performed for unstable hangman's fractures.

Settings and Design: The study design involves retrospective comparative study.

Subjects and Methods: This study conducted from 2012 to 2018 included 21 patients with unstable hangman's fracture (Levine and Edwards Type II, IIa and III). All patients were divided into two groups based on the approach taken for fracture fixation (Group A-anterior approach and Group B-posterior approach). Peri-operative clinical, radiological parameters, postoperative complications, and outcomes were evaluated and compared in both the groups.

Statistical Analysis Used: Chi-square test and Student's *t*-test were used.

Results: The mean age was 39.8 ± 4.5 years in-group A and 41.3 ± 6.7 years in-group B. The male patients outnumbered the female patients and road traffic accident was the most common cause of unstable fractures. There were statistical significant differences in surgical time ($P = 0.15$), operative blood loss, pain-free status postsurgery, and hospital stay ($P = 0.15$) between two groups. No statistically significant differences noted in clinic-radiological outcomes in the form of visual analog scale and fusion rate at final follow-up between two groups at final follow-up.

Conclusions: The unstable hangman's fractures can be effectively managed with both anterior and posterior approaches with comparable clinico-radiological outcome. A minimally invasive nature, earlier pain-free status, early mobilization with reduced hospitalization make the ACDF efficacious, particularly in cases with no medullary canal in C2 pedicles and traumatic C2–3 disc herniation with listhesis compressing the spinal cord.

Keywords: Anterior approach, cervical spine surgery, fusion, Hangman's fracture, management, pedicle screw, posterior approach, spinal instrumentation, traumatic spondylolisthesis of C2

INTRODUCTION

The traumatic spondylolisthesis of the axis or so-called hangman's fracture is characterized by a bilateral pars fracture and avulsion through the neural arch of the axis from its vertebral body.[1] In some complex and unstable cases, it is also associated with a disruption of the C2–C3 disc and ventral dislocation of the C2 vertebral body relative to C3. Levine and Edwards have classified hangman's fracture and have considered Type II, IIa, and III to be unstable variety and required to be treated surgically with rigid immobilization.[2] Various conservative and surgical management strategies have been described in the literature for hangman's fractures including traction and external immobilization,

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anterior cervical discectomy and fusion (ACDF) at C2–C3, posterior fixation and combined (anterior and posterior) approach.[3-10] However, standard treatment strategies for unstable hangman's fractures are still controversial with respect to approach related morbidities, complications, and clinico-radiological outcomes. Due to its technical simplicity, posterior techniques (C2 transpedicle screw, C2–C3 fixation, arthrodesis from C1 to C3, and occipitocervical fixation) are preferred by many authors.[2,3,5,6,8,11] However certain conditions such as C2 body fracture or C2–C3 disc herniation demands for anterior approach and techniques for providing direct decompression and short fusion/fixation.[12,13] Although both approaches and techniques have been in use since many years for unstable hangman's fracture,[10] there is still paucity of reports comparing and evaluating the efficacy and long-term clinico-radiological outcomes of ACDF and posterior fixation at C2–C3 for the treatment of unstable hangman's fractures.

The aim of this study is to compare the efficacy, clinical-radiological outcomes, and complications of ACDF and posterior fixation techniques performed for unstable hangman's fractures.

SUBJECTS AND METHODS

This was a retrospective comparative study of prospectively collected and maintained data. The hospital ethics and review committee had approved this study. Twenty-one patients with unstable (Levine Edward Type II, IIa, and Type III) traumatic spondylolisthesis of C2 over C3 operated at single tertiary care referral institute from 2012 to 2018 were included in this study. Only unstable fracture varieties with axial pain, neck stiffness, and neurological deficit were subjected to surgery after failed conservative options with absolute surgical indications and reviewed in this study. Most of the patients suffered injury due to road traffic accident and few due to domestic falls. All have received primary treatment with Philadelphia cervical collar before presentation for the surgery. Radiographic evaluation of cranio-cervical junction with X-ray, computed tomography (CT) scan, and magnetic resonance imaging (MRI) with angiography was done preoperatively and fractures classified according to Levine Edwards classification. All patients underwent preoperative Crutchfeild cervical traction with 5 kg of weight at an appropriate angle according to injury mechanism and fracture pattern. A single experienced surgeon performed all anterior and posterior surgeries. Twelve patients underwent ACDF at C2–C3 level (Group A), nine patients were managed with posterior approach and instrumented fusion procedures (Group B). The author's indications for ACDF were traumatic C2–C3 disc herniation, anterior displacement and angulation of C2 over C3, narrow pedicles of axis (<4 mm) as confirmed with the preoperative X-ray, CT scan, and MRI. All other patients with unstable variety underwent posterior surgeries (C2 pedicle screw and C3 lateral mass screw fixation). Preoperative clinical and demographic data, intra-operative parameters such as blood loss, neuro-vascular injury, and surgical time were recorded in all patients in both the groups [Table 1]. Postoperative pain free status, hospital stay, neurological recovery, and complications were documented in both the groups. Clinical outcome score visual analog scale (VAS) and neurological evaluation with the American Spinal Injury Association (ASIA) scale[14] were evaluated at regular intervals and at final follow-up. Radiological outcome was evaluated with dynamic cervical spine X-ray and CT scan at 3 months, 6 months and at 1-year follows-up. Statistical analysis was performed using the IBM Statistical Package for the Social Sciences (SPSS version 18.0) software and *t*-test for independent samples was used to analyze differences in surgical time, operative blood loss, hospital stay, pain free status, and postoperative complications between the two groups. A value of $P < 0.05$ was considered statistically significant.

Surgical techniques

Anterior cervical discectomy and fusion

The patient was placed in the supine position on radiolucent table with the neck slightly extended and 5 kg of weight used to provide axial cervical traction. Anterior high cervical retropharyngeal approach was utilized with horizontal incision made midway between the angle of the jaw and the thyroid cartilage. Microscope assisted C2–C3 anterior disc exposure done with meticulous hemostasis. After discectomy and end plates preparation, autologus bone graft along with Polyetheretherketone cage was placed to snuggly fit into the intervertebral space. An appropriate low profile locking plate was placed to allow sufficient purchase on the C2 and C3 vertebral bodies and final alignment was achieved by tightening the screws [Figure 1]. The wound was closed

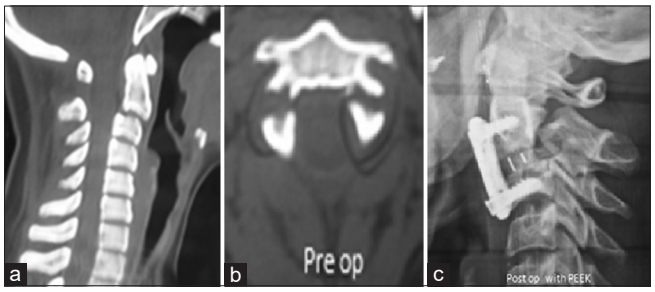

Figure 1: (a) Lateral cervical spine X-ray showing Levine Edward Type 2 unstable hangmanæs fracture with listhesis. (b) Axial computed tomography scan of cervical spine showing bilateral pars fracture of the C2 in the same patient. (c) Lateral cervcial spine X-ray showing anterior cervical discectomy and fusion done at C2–C3 leval

Table 1: Patient demographic and clinical data

Parameters	ACDF group (n=12)	Posterior fixation group (n=9)	Total (n=21)
Age (years)	39.8±4.5	41.3±6.7	-
Sex			
Male	10	8	18
Female	2	1	3
Mode of injury			
RTA	10	9	19
Domestic falls	1	1	2
Associated injuries			
Head injury	4	3	7
Facial injury	2	2	4
Thoraco-lumbar spine fracture	0	1	1
Lower cervical spine fracture	0	1	1
Fracture of extremities	3	2	5
Fracture of the mandible	2	1	3
Fracture type (Levine-Edward classification)			
II	6	5	11
IIa	4	3	7
III	2	1	3
Neurological status (ASIA scale)			
C	1	1	2
D	2	1	3

ACDF - Anterior cervical discectomy and fusion, RTA - Road traffic accident, ASIA - American spinal injury association

in layers without drain. A soft cervical collar was used for 3–4 weeks postoperatively. All patients were mobilized out bed on the next day.

Posterior instrumented fusion

For patients who underwent posterior approach, the patient was placed in prone position with head resting in a horseshoe shaped headrest with gardener's cervical tongs. The upper cervical spine was routinely exposed. The C2 pedicle screw with entry point at the superior and medial quadrant of the isthmus of C2 with the insertion angle about 20° medial and 25° superior was placed. The entry point of C3 lateral mass screw was the centers of the C3 lateral mass with the insertion angle 20° outward in the transverse plane. The cortex was burred at the entry point by a high-speed drill and screws were then inserted under fluoroscopy guidance. The properly measured rods were bent and then connected to the screws with locking caps. The articular cartilage of the C2–C3 decorticated with high-speed drill and allograft bone was placed in these areas [Figure 2]. The surgical wound was closed in layers with a submuscular drain which was removed within 48 h postsurgery or when the outcome was <50 ml. All the patients were mobilized the next postoperative day with soft cervical collar.

RESULTS

All the patients with unstable hangman's fracture (Levine Edward Type II and Type III) were divided into two groups

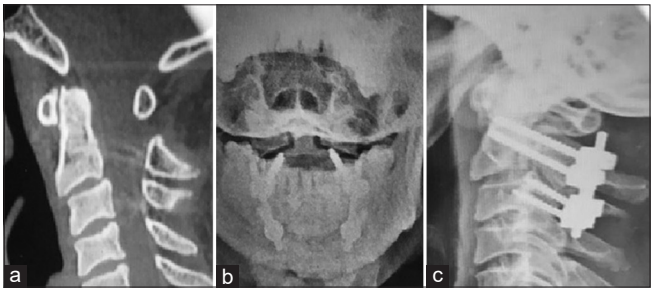

Figure 2: (a) Lateral cervical spine X-ray showing unstable hangmanæs fracture with mild listhesis and associated fracture of odontoid. (b) Cervical spine AP view showing posterior fracture fixation with good reduction and alignment. (c) Cervical spine lateral view showing posterior fracture fixation with fracture and listhesis reduction

as follows: Group A (ACDF) and Group B (posterior fixation group). The mean age was 39.8 ± 4.5 years in-Group A and 41.3 ± 6.7 years in Group B [Table 1]. The male patients outnumbered the female patients in both the groups. The majority of injuries were due to road traffic accidents (90.4%, 19/21) and domestic fall was noted in one patient in each group [Table 1]. The head injury was the most common associated injuries followed by extremities fractures and facial injuries in both the groups. Slightly more than half of the patients (52.3%) were Levine-Edwards Type II unstable fractures, followed by Type IIa (33.3%) and Type III (14.2%) [Table 1]. The common clinical symptoms such as neck pain, stiffness, and restricted motion of cervical spine were found in all patients in both the groups. Neurological deficits (ASIA Grade C or D) occurred in

five (23.8%) patients [Table 1]. Twelve cases underwent ACDF and nine cases received posterior fixation surgeries. The mean intra-operative blood loss was 80.3 ± 15 ml in-Group A and 160.5 ± 31.6 ml in-Group B that was statistically significant ($P = 0.001$) [Table 2]. No intra operative surgical complication was reported in the ACDF group. Excessive bleeding in-Group B was mainly due to injury to the venous plexus, which occurred in four cases during surgery that was managed with cottonoids and gelfoam compression. The mean surgical time was 88.15 ± 22.1 min in-Group A and 134.3 ± 29.8 min in-Group B that was also statistically significant ($P = 0.006$) [Table 2]. None of the patients received blood transfusion in any groups. All surgeries were uneventful with no intra-operative or postoperative neurological worsening or other complications. The mild dysphagia to solid food was common in-Group A patients and persisted for 3–4 weeks before complete resolution. Preoperative clinical symptoms such as neck pain, stiffness, and paresthesia were improved significantly in both the groups. The mean hospital stay was 5.5 ± 1.67 days in-Group A and 6.45 ± 1.76 days in Group B ($P = 0.22$) [Table 2]. Clinical outcome in the form of VAS score showed significant improvement in all patients in both groups but no statistical significant difference noted between the two groups at final follow-up ($P = 0.795$) [Table 3]. The authors also recorded the time required to become pain free postsurgery in both groups and found that it was statistically significant ($P = 0.003$) between two groups with posterior surgery patients requiring longer time to become pain free [Table 3]. A solid bony consolidation with adequate fusion noted in all the patients by 6–8 months postsurgery in both groups which was assessed with dynamic cervical spine X-ray and CT scan. None of the patients from two groups developed any implant-related complications and pseudoarthrosis in the follow-up period. At the final follow-up, five cases with ASIA C or D grade improved to ASIA E. None of the patients complained of limited mobility of cervical spine in flexion, extension, and rotation in-Group A, but three patients in-Group B complained of some limitations of cervical terminal motion at final follow-up.

Table 2: Surgical and clinical parameters

Parameters	ACDF group ($n=12$)	Posterior fixation group ($n=9$)	*P*
Operative time (min)	88.15±22.1	134.3±29.8	0.0006
Intra-operative blood loss (ml)	80.3±15	160.5±31.6	0.0001
Hospital stay (days)	5.5±1.67	6.45±1.76	0.222
Follow up (months)	36.2±8.8	36.1±8.9	0.979

ACDF - Anterior cervical discectomy and fusion

Table 3: Clinical and radiological outcome at final follow-up

Parameters	ACDF group ($n=12$)	Posterior fixation group ($n=9$)	*P*
Preoperative VAS	7.7±1.42	7.6±1.14	0.864
Postoperative VAS	3.12±0.22	3.03±1.17	0.795
Pain free status postsurgery (weeks)	1.4±1.2	2.3±1.3	0.003
Fusion	12	9	-

VAS - Visual Analog scale, ACDF - Anterior cervical discectomy and fusion

DISCUSSION

The surgical treatment and preferred approach for unstable hangman's fracture are still controversial. Unstable hangman's fracture are indicated with certain signs of instability like marked angulation (>11°) of C2 on C3, an anterior translation >3 mm and a displacement of the fracture on initial lateral radiographs.[15] The absolute conditions necessitating surgery[2] include the dislocated Type IIA fractures, dislocated Type II fractures (anterior translation >3 mm) and Type III hangman's fractures combined with a traumatic C2–C3 disc herniation compromising the spinal cord and established nonunions. In this study, all displaced hangman's fractures were diagnosed as having intervertebral disc injury on preoperative MRI and this was confirmed by intra-operative pathological findings. Nonoperative treatment of these injuries was associated with a significant rate of failure, instability, and delayed union with neurological worsening.[16] Hur *et al*. concluded that ACDF with plate was a feasible technique which provides immediate stability and allows for the early ambulation of patients.[17] Roy-Camille *et al*. described the C2–C3 posterior screw-plate fixation technique that has become increasingly popular.[18] Jeong *et al*. and other study have found that posterior fixation was biomechanically an effective treatment for unstable Hangman's fracture.[19,20] However intra-operative difficulties have been found during the placement of C2 screws with widening of the fracture gap and posterior elements might get detached from the C2 vertebral body which is angulated and dislocated.[21,22] Although both ACDF and posterior fixation and fusion procedures for unstable hangman's fracture are time tested and effective surgical procedures, the authors hypothesize that ACDF is a simpler procedure with advantages such as minimal soft-tissue damage, reduced intra-operative blood loss, shorter operative time, no need of sub-muscular drain, early pain free status, and reduced hospital stay. The posterior approach is associated with dissection of the posterior cervical muscles, excessive bleeding due to injury to the venous plexuses, longer operative time, and more postoperative drainage. The only advantages of this procedure is direct fixation of the pars fracture of C2 with a simplicity of exposure and preservation of motion of the axis.[23] However, direct pars repair does not address instability at the disc and the disruption of the anterior and/or posterior longitudinal ligament and therefore, it can

be used only in cases with minimal or no injury to C2–C3 disc.[24] The highly variable anatomy of the upper cervical spine, vertebral artery anomalies, and other surrounding structures like the spinal cord and nerve roots make posterior approach a highly demanding procedure.[23,25] The lack of the medullary canal in C2 pedicles with too narrow and deformed C2 pedicles render screw placement difficult and such cases are contraindicated for posterior fixation surgeries.[26] As this is a high-risk procedure, many surgeons prefer the anterior approach. Liu *et al*.[27] believed that posterior approach for a highly unstable hangman's fracture may aggravate forward displacement of C2 because of the prone surgical position and the forward thrust of the C2 screw, particularly with the extremely unstable state of C2. This aggravation causes iatrogenic injury and may lead to extremely serious consequences. Certain contraindications like lack of the medullary canal in C2 pedicles, too narrow and deformed C2 pedicle are indications for the anterior approach. Moreover, the supine position and the procedure of the placement of anterior plate and screws under microscope facilitate reduction of anterior displacement of C2 body. However, the anterior approach has disadvantages like injuries to the facial and hypoglossal nerves, branches of the external carotid, and the superior laryngeal nerve.[28] With steep learning curve and experience, the anterior approach offers precise primary stability with anatomic reduction of displaced C2 over C3 with reconstruction of cervical spine.[29] By using the casper retractor, one may achieve some extent of reduction, reconstruct the cervical lordosis, and get favorable results. Analyzing the results of this study, none of the aforementioned surgical techniques has proven superiority in terms of fusion rates, mortality, and complications.[30] Hence, treatment selection should be based on fracture classification, proper radiological study, experience of the surgeon, and potential patient comorbidities. At 2 years follow-up, the clinico-radiological outcomes and postoperative complication rate were comparable in both groups in this study. However, less invasive nature, simpler technique, reduced intra-operative blood loss, better reduction of listhesis and achieving the lordosis with excellent clinical outcomes, faster postoperative recovery, reduced hospitalization and no long-term surgical complications make ACDF an effective and safe surgical procedure to manage the unstable hangman's fracture. Although in this study, the incidence of mild dysphagia was significant in anterior group patients and time required to become pain free postsurgery was longer in posterior group. Certain measures indicated in previous studies such as trachea stretch exercise, avoiding prolonged, and significant stretching of the trachea during surgery, and atomization inhalation therapy of alpha chymotrypsin, mucosolvin, dexamethasone after the surgery have been found useful to reduce the incidence of dysphagia in author's subsequent patients.

Its retrospective nature, nonrandomized design and small number of patients are some limitations of the current study. The study requires further confirmation by multicenter prospective studies involving more cases. The short-term follow-up of 2 years can be one of the limitations. A surgeon's experience and training could modify the outcomes; however, in this study, single experience surgeon performed both the approaches in all patients. A lack of comparison of ACDF with other posterior fixation techniques different from author's technique might be a limiting factor.

CONCLUSIONS

The unstable hangman's fractures can be effectively managed with both anterior and posterior approaches. A comparable clinico-radiological outcome in the form of satisfactory improvement of neck pain, neurologic status, cervical spine motion, and solid bony fusion were noted with both approaches in this study. A minimally invasive nature, earlier pain free status, early mobilization with reduced hospitalization make the ACDF efficacious, particularly in cases with no medullary canal in C2 pedicles and traumatic C2–C3 disc herniation with listhesis compressing the spinal cord.

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Conflicts of interest
There are no conflicts of interest.

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