C1-C2 FIXATION WITH C1 LATERAL MASS AND C2 PARS SCREWS, A CASE SERIES: TECHNIQUE AND OUTCOMES

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ABSTRACT

Background: Atlantoaxial fixation can be done either trans-orally, through the anterior retropharyngeal route, laterally or posteriorly. The posterior approach is the most frequently utilized. Posterior fusion with C1 lateral mass screws and C2 pars screws has been shown to produce better clinical outcomes than posterior C1/C2 wiring. In addition, it is safer than the C1 lateral mass-C2 pedicle screw construct (Goel-Harms technique) and biomechanically as strong.

Objective: To describe the results of a case series of C1-C2 fixation via C1 lateral mass and C2 Pars screws for traumatic C1-C2 injuries at AIC Kijabe Hospital and Nakuru Teaching and Referral Hospital in Kenya.

Design: This was a retrospective review of prospectively collated data between 2016 and 2019.

Methods: All the eight patients, with an average age of 37 years, were followed up for at least six months after surgery; and all had C1-C2 instability secondary to significant trauma. There were six male and two female patients. The ASIA Impairment Scale and Oswestry Neck Disability Index were the clinical outcome measuring tools. Radiographically, plain X-rays and/or CT scan were used to assess radiologic union.

Results: Clinically, no patient deteriorated and all (100%) attained ASIA Scale E. On the Oswestry Neck Disability Index grading, there was no disability in one (12.5%) and minimal disability in seven (87.5%). All (100%) of the patients attained radiographic union. There was one (12.5%) acute deep infection in a diabetic patient.

Conclusion: The use of C1 lateral mass screws and C2 pars screws is safe and effective for fixation of C1-C2 instability.

Key words: C1 lateral mass screw, C2 pars screw, Fixation, Oswestry, ASIA

INTRODUCTION

The atlantoaxial joint has complex biomechanical properties as a result of its unique anatomy, which permit a high level of mobility (1). Its intrinsic stability is primarily from ligamentous structures (2). Trauma, degenerative conditions, infections, neoplasms, congenital anomalies and previous surgery can cause atlantoaxial instability (1,3). Various techniques to restore atlantoaxial stability have evolved over the years. Prior to the development of the modern rod-screw fixation technique,fixation armamentarium was limited to posterior wiring methods augmented with either halo-vests, casting or collars (3). The use of posterior screw constructs for atlantoaxial fixation has emerged as a popular technique due to higher fusion rates and better biomechanical stability (1). Several options are available, and the surgical technique must be individually tailored to the patient's anatomy (3). Jeanneret and Magerl (4) technique entails placing a trans-articular screw (posteriorly) through the C1-C2 articular surfaces. Other techniques such as the Goel-Harms C1 lateral mass-C2 pedicle screw (C1LM-C2PS) construct, the Wright C1 lateral mass-C2 translaminar (C1LM-C2TL) screw construct, and the C1 lateral mass-C2 Pars (C1LM-C2 Pars) screw construct (3,5-8) have been utilized. C1LM-C2 Pars construct is resorted to due to suitability in patients with unfavorable anatomy like a 'high-riding' vertebral artery; and has better flexion-extension and lateral bending stabilities (1).

MATERIALS AND METHODS

A retrospective review of prospectively collected data of eight patients who had C1LM and C2 Pars screw fixation was done. All patients had surgery between the year 2016 and 2019 by the senior author(AMM). The surgeries were performed in two hospitals that are classified as national teaching and referral hospitals. They were followed up for an average of 22 months. The demographic data, pathology, surgical technique and complications are illustrated in Table 1. Some patients' fixation extended to the sub-axial spine as noted in Table 1.

Table 1

A tabulation of the demographics and results

Patient	Age (Years)	Gender	Pathology	Extension of fixation to sub axial spine	Oswestry Neck Disability Index (Grade)	ASIA Scale (Preop➔Postop)	Complication(s)
LK	11	M	Atlantoaxial Rotatory Instability (AARI)	No	No disability	D➔E	Nil
GM	70	F	C2 Pars Fracture	Yes	No disability	E➔E	Blow-out of C3 lateral mass
HN	48	F	C2 Pars Fracture	Yes	No disability	E➔E	Deep SSI
JM	26	M	Lateral C1-C2 traumatic instability	No	Moderate disability	E➔E	Nil
MM	33	M	Lateral C1-C2 traumatic instability	No	No disability	E➔E	Nil
PW	47	M	Anterior C1-C2 traumatic instability	No	No disability	D➔E	Nil
SM	35	M	Odontoid fracture	No	No disability	E➔E	Nil
BO	25	M	C2 Pars fracture	Yes	No disability	E➔E	Nil

All patients were operated in prone position after general anaesthesia and head positioned on a Mayfield headrest. In addition, all had skull traction via a Gardner-Wells tong (15-20lbs) (Figure 1). Spinal cord monitoring was not utilized and only one patient had preoperative CT angiography to map-out the vertebral artery (patient had atlantoaxial rotatory instability). A midline posterior incision was used to initiate the exposure that progressed to sub-muscular dissection. The C1 lateral mass was accessed by retracting the C2 nerve root inferiorly; and required scrupulous control of bleeding from the venous plexus around the C2 nerve root (3,9). The bleeding was controlled mainly by use of Surgicel (Ethicon) and gentle use of bipolar electrocautery (3). The C1 screw was inserted after predrilling (first by use of a power drill/high speed burr to breach the cortex then by freehand) and the trajectory was 10-15^0 cranially and 10-15^0 medially; screw lengths were typically 22-28mm (Figure 2). The C2 Pars screw was inserted using a starting point 2-3mm superior and lateral to the medial aspect of the C2-C3 facet joint and aimed 10^0 medial and 45^0 cranially; with screw lengths of 14-18mm used (Figure 3). In addition, three (37.5%) of the patients had a Gallie-type C1 loop wiring (gauge 20-22 wire) to help reduce displaced fractures prior to screw fixation (Figure 3b). This wire was not removed but used as part of definitive fixation by anchoring it to the base of the C2 spinous process (Figure 3c).Implant position was confirmed using an image intensifier (GE 9900 Elite). Finally, posterior iliac crest bone graft was harvested and applied to decorticated (we prefer to use a high speed burr and Leksell rongeur) surfaces; prior to a multilayered closure (using PDS®/Vicryl® and Monocryl® sutures) over a Hemovac® (closed suction) drain which was removed after 24-48 hours. In addition, 500mg-1gm vancomycin powder was spread on the implants and bone graft prior to closure. A hard collar was applied prior to reversing the anaesthesia and kept for 2-3 months with a weaning period of 2-4 weeks using a soft-collar. Patients were followed up in clinic at 2,6,12 weeks, 6, 9 and 12 months. AP (trans-oral) and lateral radiographs were done immediate postoperatively and at 6,12 weeks, 6, 9 and 12 months. The clinical outcome was assessed using the ASIA Impairment scale and Oswestry Neck Disability Index; and radiologic healing was assessed by ascertaining presence of bridging bone across fractures/motion segments on X-ray/CT scan or maintenance of reduced alignment.

Figure 1
Shows an actual patient prone set-up in theatre. The head is on a Mayfield headrest with traction via Gardner-Wells tongs; the balanced traction is using the Mayo stand as a pulley, secured at the base with 6 filled up 5-litre jerrycans

Figure 2a
An artistic drawing showing the starting point for the C1 lateral mass screw (arrows)

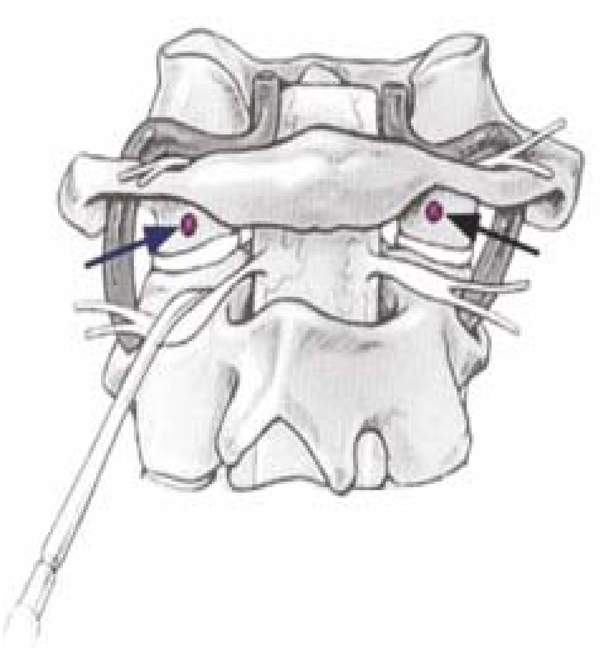

Figure 2b
Drawing depicting the aerial/axial view with both C1LM screws in situ

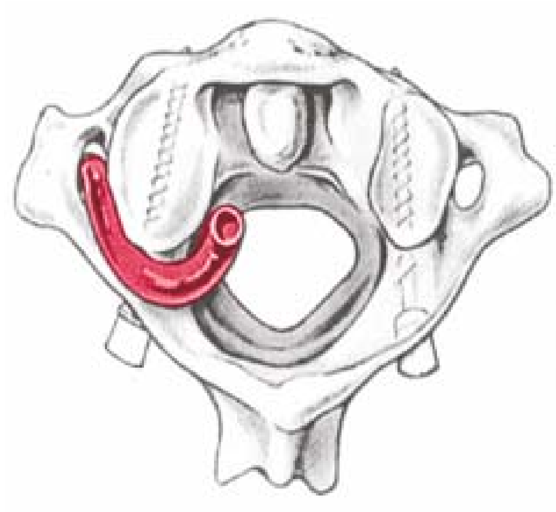

Figure 2c
Intraoperative fluoroscopic lateral view image showing the actual C1LM in situ (for fixation of an Odontoid II fracture-block arrow)

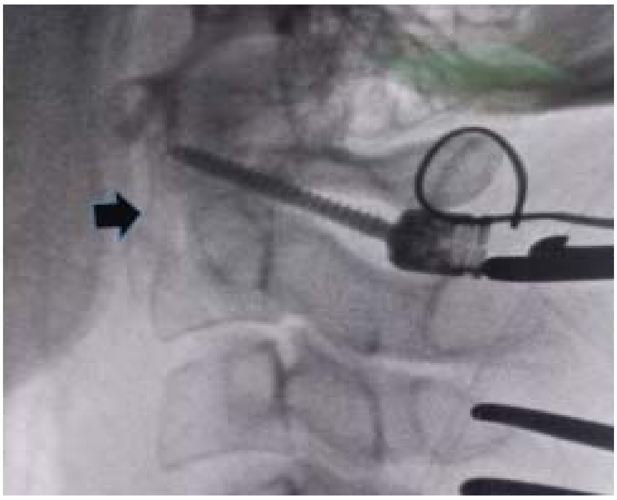

Figure 3a
The black line indicates the trajectory for the C2 Pars screw

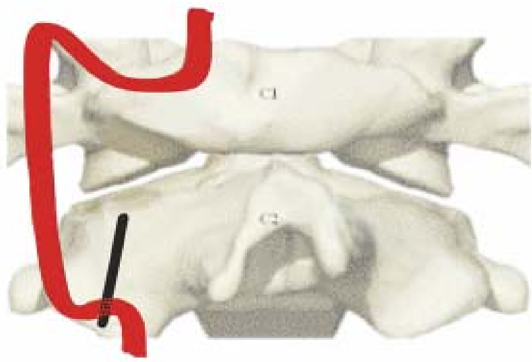

Figure 3b
Intraoperative, fluoroscopic lateral image showing the C2 Pars screw in situ (block arrow); and the Gallie-loop wiring (arrow) used to aid fracture reduction

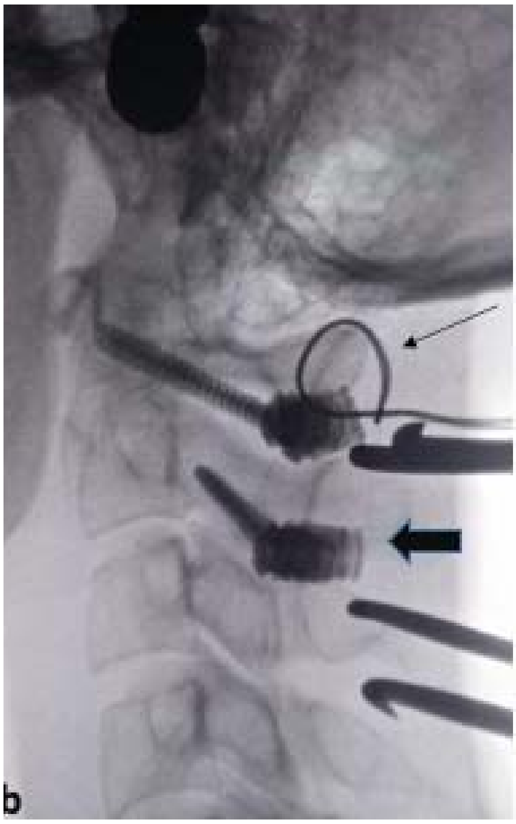

Figure 3c
Intraoperative, fluoroscopic lateral image showing the final fixation with the C1 LM-C2 Pars fixation and Gallie wiring (left in situ)

RESULTS

Eight patients were included in the study and the demographics are included in Table 1. The average age was 37 years (11 to 70 years). All patients had post-traumatic injuries with resultant C1-C2 instability. Two patients (25%) had preoperative neurologic impairment (ASIA D) and all eight (100%) were ASIA E by the 6th month postoperatively. On the Oswestry Neck Disability index scale, all (100%) the patients had minimal disability. All (100%) patients attained bony healing/fusion. Four patients (50%) needed sub-axial extension of the fixation due to the presence of sub-axial instability (Figure 4). One patient (12.5%) who had poorly controlled diabetes mellitus at admission, developed acute deep surgical site infection; but she was debrided without removing the hardware and didn't get a recurrence. One patient (12.5%) who was elderly (70 years old female), had one of her lateral masses break-off during screw insertion but got supplemental screws caudally with a good fixation ultimately.

Figure 4a
Posterior view of a 3D CT reconstruction showing bilateral displaced C2 pars fractures (red arrows)

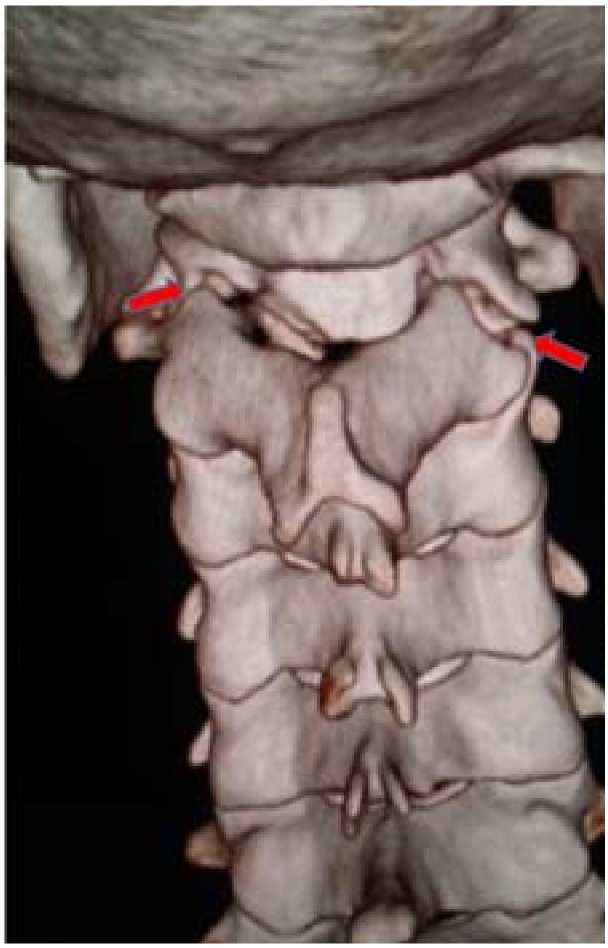

Figure 4b
Lateral view of the 3D CT showing the right C2 pars fracture with subluxed right C2-C3 lateral mass joint (blue arrows)

Figure 4c
Intraoperative, fluoroscopic lateral view image showing C1 LM-C2 Pars fixation with extension to the C3 lateral masses due to the unstable C2 C3 joint

DISCUSSION

Posterior cervical spine fixation has undergone tremendous advancement in the last three decades; and the use of screw-rod constructs for atlantoaxial fixation, has emerged as a popular alternative to posterior wiring and graft techniques (1,3). Several screw-rod options exist and the technique is selected based on the patient's vascular-osseous anatomy, the specific pathology and the experience/comfort level of the surgeon (1). Currently, there are several affordable screw-rod constructs in developing countries.

Magerl and Seemann (10) introduced C1-C2 trans-articular(C1-C2TA) screw fixation in 1986;and it provided better stability(with regard to lateral bending and axial rotation) and higher fusion rates (92.9%). Tied to this are several disadvantages, the first being the need to have complete reduction of C1 over C2 to place the C1-C2TA screw and also may be unsuitable for patients with a fixed thoracic kyphosis or obesity(precludes the steep angle of approach required for screw insertion (11). In addition, it's ineligible in 23.5% of patients because of a 'high-riding' vertebral artery (12).

In 1994, Goel and Laheri (5) first described the C1LM-PS technique but it did not win much recognition. Its use gained popularity in 2001 when Harms and Melcher (6) published a study of 37 patients who had C1-C2 fusion using the C1LM-PS construct but with poly-axial screws and rods unlike Goel and Laheri (5) who used a plate and screws. Further, Harms and Melcher (6) recommended preserving the C2 nerve root by dissecting around it and retracting it caudally with control of bleeding using bipolar coagulation and tamponade; this was unlike Goel and Laheri (5) who described complete rhizotomy of the C2 nerve root. C1LM-PS construct does not require reduction of C1 over C2 prior to screw placement and it's technically less demanding than the C1-C2TA technique (1). Only 9% of patients are anatomically unsuitable for this surgical method due to the Vertebral Artery (VA) course and/or C2-pedicle hypoplasia (1). Reported fusion rates for the C1-C2PS construct range from 88.2% to 100% (13). Goel and Laheri (5) and Harms and Melcher (6) achieved 100% C1-C2 fusion. In all our cases, we dissected around the C2 nerve for C1LM screw insertion as Harms and Melcher (6) recommended with some patients developing transient occipital neuropathy(numbness or occipital pain).

Further along, in 2002 Resnick and Benzel (14) published a case report of C1-C2 fixation using the Goel and Harms technique but with only 20mmlong screws (didn't reach the anterior cortex) and combined it with a sublaminar cable using a modified Gallie technique. Their patient was extremely obese and thus, they recommended their technique as an alternative to the C1-C2TA construct when there is an anomalous VA course and unfavorable patient physical condition. We also used a modified Gallie wiring in 5(62.5%) of our patients to aid in reducing the fracture(s) prior to screw insertion and the wires were left *in situ.*

The C1LM-C2Pars and C1-C2TL constructs have been resorted to as alternatives to C1-C2TA and C1LM-C2PS constructs due to their suitability in patients with unfavorable anatomical features for instrumentation into the C2 pedicle or across the C1-C2 joint e.g. hypoplastic C2 pedicle, high riding vertebral artery or bone loss from pathologic lesions(1). Elliot *et al* (15) found a slightly higher incidence of vertebral artery injury in C1LM-C2PS constructs than in C1LM-C2 Pars constructs in their meta-analysis. On the contrary, they found higher fusion rates with C1LM-C2 PS constructs (97.8%) than with C1LM-C2 Pars constructs (93.5%). In our case series study, none of the patients had a vertebral artery injury and all our patients progressed to bony fusion (100%).

As regards stability, Du *et al* (1) in their meta-analysis, found that the C1-C2 TA and C1LM-C2 Pars constructs provided better lateral bending stabilization than the C1LM-C2 PS and C1LM-C2 TL constructs. In addition, the C1LM-C2 Pars construct provided more flexion/extension stabilization than other constructs but the least axial rotation. The better stability in screw constructs especially the C1LM-C2 Pars may explain the better fusion rates of screw constructs like in our study.

Beyond the biomechanics, we did assess the clinical outcomes. None of the patients deteriorated clinically as all (100%) attained ASIA E as of last follow-up. The two patients (25%) who had a preoperative ASIA D start point, ended up as ASIA E after the C1LM-C2 Pars fusion. On the Oswestry Neck Disability index all but 1 patient had no disability (87.5%) postoperatively.

Complications were few; 1 (12.5%) had a lateral mass blow-out during insertion and needed caudal extension of the construct and she was an elderly (70-year old female) patient who went on to successful fusion. In addition, one (12.5%) patient who had poorly controlled diabetes mellitus at admission, developed deep surgical site infection but was debrided once and progressed to bony fusion with no infection recurrence.

CONCLUSION

This study demonstrates that good outcomes are not quixotic in resource limited set-ups like in most African hospitals. Key in managing this technically challenging and high-risk cervical spine fractures is: attainment of the necessary skills, meticulous preoperative planning, thorough knowledge of the anatomy of the upper cervical spine and familiarity with modern instrumentation and constructs (3). As regards the implants and instrumentation, there are numerous good quality and affordable poly-axial screws and rods available in most developing countries. In our cases, we used implants from two companies (Medtronics-Kanghui, Europe and Suzhou Kangli, China).

Conflict of interest: None of the authors had any conflict of interest to declare.

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