Original Research

To Evaluate The Role Of Combination Of C1-C2 Transarticular Fixation And C1 Lateral Mass Screw Fixation For The Management Of Atlantoaxial Instability

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Received date: 19 February, 2024 Acceptance date: 13 March, 2024

Abstract

Aim: To evaluate the role of combination of C1-C2 transarticular fixation and C1 lateral mass screw fixation for the management of atlantoaxial instability.

Materials and methods: This research covered all patients who were treated for AAI and had the combination procedure. The patients' records were retrospectively examined, and the clinical and radiological data recorded was analyzed in a comparable manner, comparing the preoperative and postoperative periods. The clinical results were evaluated by assessing the severity of pain before and after the surgery using a visual analog scale (VAS) for neck discomfort and pain in the C2 region. Furthermore, the Ranawat categorization of functional impairment was documented and then compared using the same approach.

Results: Out of the total of 50 patients, the VAS ratings for neck discomfort were obtainable for 40 of them. The average preoperative VAS score for neck discomfort was 6.54±1.11, but at the first postoperative review it was 4.55±1.09. This difference was statistically significant (p =0.001) based on paired comparison. The Ranawat scores before and after surgery were obtained for a total of 50 patients. The Ranawat ratings showed improvement after surgery in 16 out of 50 patients (32%), remained unchanged in 32 patients (64%), and deteriorated in only 2 patients (4%). The Ranawat score showed a substantial improvement (p = 0.01) after surgery, similar to the VAS score, according to paired analysis. Postoperative imaging of all patients confirms the stability of the construct.

Conclusion: The incorporation of C1 lateral mass screws into C1-C2 transarticular screw fixation for the management of atlantoaxial instability (AAI) is a very efficient and secure surgical technique. Our findings and expertise demonstrate that this technique is very advantageous in cases when decompression of the posterior components of C1 is necessary, and it may eliminate the need for supplementary posterior wiring often associated with posterior transarticular screw fixation.

Keywords: C1-C2 transarticular fixation, C1 lateral mass, screw fixation,Atlantoaxial instability

Introduction

The cervical spine is anatomically and functionally separated into two parts—the upper and lower cervical spines. The upper cervical spine, consisting of the C1 and C2 vertebrae, has a pliable function but an intricate architectural structure characterized by a complex arrangement of joints and ligaments[1,2]. Consequently, its complexity contributes to a wide range of structural abnormalities resulting from injury or trauma. Cervical spine injuries elevate the likelihood of experiencing serious neurological sequelae and constitute 50 to 75% of all spinal injuries[3]. Contemporary imaging techniques such as computed tomography and magnetic resonance imaging are used to identify and analyze anatomical abnormalities, which helps in determining the most suitable course of action for patient treatment. Managing atlantoaxial instability (AAI) with surgery is difficult because to its complicated anatomy and the possibility of severe consequences[4,5]. When considering stabilization of the C1-C2 complex, it is important to consider the pathological origin of the AAI, the route of the vertebral artery, the internal height of the C2 vertebra, and the degree of C1 and C2 dislocation. Various methodologies have been devised for the surgical treatment of AAI, each with its own merits and drawbacks. Over time, it has been clear that there are differences among surgeons in how they define different anatomical features and the paths that screws should follow. Irrespective of the terminology and description, it is crucial for the surgeon to be knowledgeable about many choices and screw paths in order to reduce the occurrence of difficulties[6-8]. Two commonly used surgical methods for managing AAI (atlantoaxial instability) are Magerl's C1-C2 transarticular screw fixation approach and the Goel-Harms operation. At our facility, we use a hybrid surgical approach to treat AAI, which harnesses the mechanical benefits of both the aforementioned treatments. The inclusion of C1 lateral mass fixation via a vertical posterior connecting rod combines the excellent stability in axial neck rotation offered by the transarticular screw with stabilization in flexion and extension supplied by the posterior rod connecting the C1 lateral mass. This method creates a tension band in bending, eliminating the need for the conventional C1-C2 wiring approach including posterior C1-C2 transarticularfixation[9-11]. This is particularly advantageous when decompressing the posterior parts of C1 or C2 is necessary.

Materials and methods

This research covered all patients who were treated for AAI and had the combination procedure. The patients' records were retrospectively examined, and the clinical and radiological data recorded was analyzed in a comparable manner, comparing the preoperative and postoperative periods. The clinical results were evaluated by assessing the severity of pain before and after the surgery using a visual analog scale (VAS) for neck discomfort and pain in the C2 region. Furthermore, the Ranawat categorization of functional impairment was documented and then compared using the same approach. From a radiological standpoint, all patients had both pre- and postoperative cervical dynamic radiography (CDR), as well as computed tomography (CT) and magnetic resonance imaging (MRI). The measurements of the posterior atlantodental interval (PADI) were taken during neck flexion and extension. Additional important imaging characteristics evaluated were the extent and ease of reducing atlantoaxial instability (AAI), the size of the C2 pedicle and pars to exclude the presence of elevated vertebral arteries and neural compression.

Methodology

The patients were placed on the operating table (OT) in a face-down position, with their head secured in a Mayfield head clamp. The head is bent on the neck in a military tuck posture, without applying traction, to facilitate the movement and alignment of the C1-C2 complex. Following the preparation and covering of the skin, a vertical cut is performed starting just below the inion and extending to the level of C4. The occiput, C1 arch, and the C2-C3 facet joints are exposed bilaterally using the conventional method. The transarticular screw entry site was positioned 3 mm above and 3 mm to the side of the lower inner corner of the C2-C3 facet joint. The trajectory is directed towards the front arch of C1 with the assistance of intraoperative fluoroscopy. For all of our cases, we used screws with a diameter of 4 mm and a length ranging from 44 to 46 mm. The entry locations for the C1 lateral mass screws were located in the posterior portion of the lateral mass, immediately below the posterior arch. The trajectory was aimed 10 to 15 degrees towards the center, using screws with a diameter of 3.5 millimeters. Titanium rods of limited length were inserted posteriorly, positioned between the polyaxial screws. Bilateral decortication of the C1 and C2 cortical surfaces around the screws was performed, followed by the placement of a bone graft.

Data Analysis

The data were processed using the SPSS Version 25.0. The results were reported as percentages (%), mean values with 95% confidence intervals (CI), or medians, as applicable. The statistical methods used to compare categorical and numerical variables were Fisher's exact test, Wilcoxon's signed rank test, and paired t-tests. Statistical significance was given to any p-values that were less than 0.05.

Results

The group consisted of 50 individuals who had this combination surgery. The study included a total of 50 patients, consisting of 15 male and 35 females. The average age of the patients was 61.24±6.43 years. The majority of participants belonged to the age category of 55-65 years, accounting for 44% of the total. This was followed by the age group of 45-55 years. The average duration of hospitalization after surgery was 5.25±1.12 days. Out of the group, 47 patients (94%) had surgical treatment for neck discomfort caused by instability.

Table: 1 Basic profile of the participants

	Number	Percentage	P value
Gender			0.13
Male	15	30	
Female	35	70	
Age			0.15
Below 35	4	8	
35-45	8	16	
45-55	12	24	

55-65	22	44	
65-75	3	6	
Above 75	1	2	
Mean Age	61.24±6.43		

Among the cohort of 50 patients experiencing instability, 41 patients (82%) were diagnosed with rheumatoid arthritis (RA). Additionally, 3 patients had osodontoideum, 2 patients had septic arthritis leading to instability, 2 patients had a nonunited type II odontoid peg fracture, and 2 patients had severe spondylotic myelopathy and AAI.

Table: 2 Comorbidity

	Number	Percentage
Rheumatoidarthritis	41	82
Osodontoideum	3	6
Septic arthritis	2	4
Nonunited typeII odontoidpeg fracture	2	4
Severe pondyloticmyelopathy and AAI	2	4

The median clinical follow-up after the operation was 8.55 months. Out of the total of 50 patients, the VAS ratings for neck discomfort were obtainable for 40 of them. The average preoperative VAS score for neck discomfort was 6.54±1.11, but at the first postoperative review it was 4.55±1.09. This difference was statistically significant (p =0.001) based on paired comparison.

Table: 3 VAS scores for neck pain

VAS scores	Mean	Sd	P value
Preoperative	6.54	1.11	0.001
Postoperative	4.55	1.09	

The Ranawat scores before and after surgery were obtained for a total of 50 patients. The Ranawat ratings showed improvement after surgery in 16 out of 50 patients (32%), remained unchanged in 32 patients (64%), and deteriorated in only 2 patients (4%). The Ranawat score showed a substantial improvement (p = 0.01) after surgery, similar to the VAS score, according to paired analysis. Postoperative imaging of all patients confirms the stability of the construct.

Table:4 Ranawat scores of the participants

Ranawat scores	Number	Percentage	P value
Improved	16	32	0.001
No changes	32	64	
Very poor	2	4	

The complications seen in this series consisted of three cases of unilateral intraoperative vertebral artery damage resulting from the implantation of C1-C2 transarticular screws. Additionally, one patient had aggravated C2 discomfort after the operation, and five patients reported numbness in the C2 distribution after the treatment. From a radiological perspective, it was found that three patients had unsatisfactory unilateral placement of C2 screws, even though the fluoroscopic imaging during the surgery seemed to be adequate. In all cases, the construct remained stable when seen from different angles, since the part of the screw closest to the joint acted as a screw for the C2 pars interarticularis. No postoperative infections were detected (Table 5).

Table 5: Intraoperative and postoperative complications

Complication	Type	Number	Percentage
C2 distribution numbness	Clinical-postoperative	5	10
Inability to place aC1-C2 transarticular screw	Intraoperative	3	6
vertebral artery injury	Intraoperative	3	6
C2 neuralgia	Clinical-postoperative	2	4
Suboptimal transarticular screws placement	Radiological	3	6

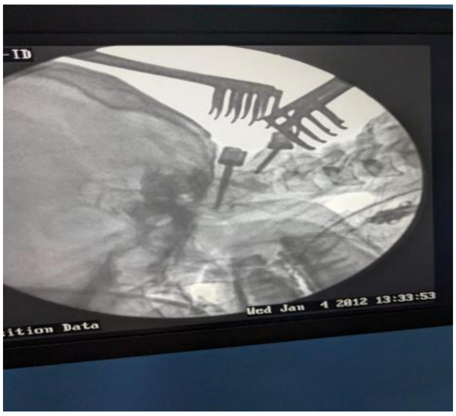

Figure1.

Figure2.

Discussion

The C1-C2 motion segment has the most extensive range of motion among all spinal motion segments. The flexion-extension range of motion is between 10° and 22°, the axial rotation range is between 23° and 38° on each side, and the lateral bending range is 6.7°. In the non-pathologic condition, there is a certain degree of sagittal translation, lateral translation, distraction, and compression. If the components of the C1-C2 motion segment are injured due to trauma, inflammation, tumor, or congenital abnormalities, it leads to an increase in the range of motion[10,11].The C1-C2 region's anatomy is intricate because of the nearby neurovascular systems. The complexity of achieving atlantoaxial stability during surgical intervention has necessitated the development of a diverse range of stabilizing methods throughout time. The previous methods of wiring/cabling the posterior region, such as those developed by Gallie, Brooks-Jenkins, and Sonntag[12,13], have been replaced by more advanced instrumentation techniques that include the use of various screws, plates, rods, and hooks for fixing the atlantoaxial region. The subsequent techniques that were developed include: Magerl and Jeanneret[14], modified Magerl and Jeanneret; Goel and Laheri[15], the Harms/Goel technique[16], C1-C2 transarticular screws combined with C1 laminar hooks[17], and the Wright technique (C1 lateral mass to crossing C2 laminar screws)[18]. The literature has also discussed the use of anterior retropharyngeal transarticular screw fixation for stabilizing the C1-C2 vertebrae[19].Posterior atlantoaxial fusion with transarticular screw fixation is often regarded as the most effective surgical procedure. While this approach provides the highest level of rotational stability, research has shown that it is not as effective in resisting bending and stretching stresses unless it is used in conjunction with a posterior wire/graft procedure. Nevertheless, wiring approaches are not applicable in cases when C1 arch decompression is required or if the post components of C1 and C2 are osteoporotic[14,20]. Conversely, cadaveric investigations have shown that the C1 lateral mass to C2 pars build provides superior stability in both flexion and extension when compared to transarticular C1-C2 screws or C1 lateral mass to C2 pedicle construct. Nevertheless, research has shown that it exhibits the lowest level of rotational stability when compared to the other two procedures[21].This series documents our firsthand encounter with a technique that involves the fusion of the C1 and C2 vertebrae using transarticular screws, along with the addition of a C1 lateral mass screw connected by rods. This structure offers a fixation with four points. The transarticular screw restricts axial rotational motions, while the remaining structure functions as a tension band, providing extra support to the joint during flexion, extension, and lateral bending actions. Our findings and expertise demonstrate that this technique is very advantageous in cases when decompression of the posterior parts of C1 is necessary, and it may eliminate the requirement for posterior wiring entirely when doing a transarticular screw fixation. We have used this approach to conduct C1 decompression in three patients within our series. Our hospital has previously reported a successful case of la Maladie de Grisel treated with this approach, demonstrating the advantageous nature of this treatment for C1 decompression[22]. We implemented this approach as a variation of the "double insurance antlantoaxial fixation" first outlined by Goel et al[23]. Goel's method included the use of a transarticular screw with a C1 lateral mass screw, together with an intraarticular spacer and a compression plate. In contrast, our variation employs polyaxial C1-2 transarticular and C1 lateral mass screws, along with a posterior rod construct solely.Based on our observations, the inclusion of a C1 lateral mass screw does not negatively affect the biomechanics of the C1-C2 transarticular screw located inside the C1 lateral mass. One may argue that the lateral mass of C1 may not have enough space to fit both the C1 lateral mass screw and the transarticular screw, or that their paths may intersect inside the C1 lateral mass. Upon reviewing our postoperative imaging, we found no indication of contradictory screw trajectories within the bony cortex.Out of the total of 50 patients, the VAS ratings for neck discomfort were obtainable for 40 of them. The average preoperative VAS score for neck discomfort was 6.54±1.11, compared to 4.55±1.09 at the first postoperative assessment. This difference was statistically significant (p =0.001) based on paired comparison. The Ranawat scores before and after the surgery were obtained for a total of 50 individuals. The Ranawat scores showed improvement in 16 out of 50 patients (32%), remained unchanged in 32 patients (64%), and deteriorated in only 2 patients (4%). The Ranawat score showed a substantial improvement (p = 0.01) after surgery, similar to the VAS score, as seen in the paired analysis. Postoperative imaging of all patients confirms the stability of the construct.Every one of the 50 patients in the study demonstrated postoperative stability when examined with dynamic X-rays. No instances of implant failures were documented. The complications seen in this series included of three cases of unilateral intraoperative vertebral artery damage occurring during the implantation of C1-C2 transarticular screws, one patient experiencing worse C2 discomfort after surgery, and five patients reporting numbness in the C2 distribution after the treatment. From a radiological perspective, it was found that 3 patients had unsatisfactory placement of a single screw in the C2 vertebra, despite the use of good fluoroscopic imaging throughout the surgery. In all patients, the construct remained stable when viewed dynamically, since the proximal part of the transarticular screw acted as a C2 pars interarticularis screw. This is within the documented range (0-10%) for transarticular fixation without computer-assisted navigation, as seen in the literature [6,7]. Although this case series is a modest retrospective research conducted at a single facility, it nonetheless presents a noteworthy surgical method. We have not yet identified the fusion rates over a long period of time, and we want to investigate this, along with the biomechanical characteristics of this structure. Furthermore, we want to use image-guidance technology to enhance the precision of screw insertion, minimize the occurrence of vascular damage, decrease surgical time, and reduce radiation exposure.

Conclusion

The incorporation of C1 lateral mass screws into C1-C2 transarticular screw fixation for the management of atlantoaxial instability (AAI) is a very efficient and secure surgical technique. Our findings and expertise demonstrate that this technique is very advantageous in cases when decompression of the posterior components of C1 is necessary, and it may eliminate the need for supplementary posterior wiring often associated with posterior transarticular screw fixation.

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