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C2 Intralaminar Screw Placement: A Quantitative Anatomical and Morphometric Evaluation

C2 İntralaminar Vida Yerleştirilmesi: Kantitatif Anatomik ve Morfometrik Değerlendirme

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ABSTRACT

AIM: To investigate the feasibility of placing a screw in the C2 lamina and evaluate the reliability of the surface of the dorsal arch of C2 as a landmark for determining the optimal site of screw entry.

MATERIAL and METHODS: 88 adult human C2 spines were used. Seven measurements were determined for screw entry points, trajectories, and lengths for placement of intralaminar screws.

RESULTS: The average width of right C2 lamina (1/3 upper segment) was 2.6 mm (1.2 to 4.1 mm). The average width of left C2 lamina (1/3 upper segment) was 2.6 mm (1 to 4 mm). The average width of right C2 lamina (1/3 middle segment) was 4.9 mm (2.6 to 6.8 mm). The average width of left C2 lamina (1/3 middle segment) was 4.9 mm (2.3 to 7.6 mm). The average width of right C2 lamina (1/3 lower segment) was 5.7mm (3.3 to 8.2 mm). The average width of left C2 lamina (1/3 lower segment) was 5.8 mm (2.2 to 9.6 mm).

CONCLUSION: The width of the upper one-third of C2 lamina is not appropriate for the placement of intralaminar screws. On the other hand, the width of the middle and lower one-third of C2 lamina is more convenient for intralaminar screw delivery.

KEY WORDS: Axis, C2, Intralaminar screw, Lamina

ÖZ

AMAÇ: Optimal vida giriş yerini tanımlamak için bir landmark olarak C2'nin dorsal arkının yüzeyinin güvenilirliğini değerlendirmek ve C2 laminasına bir vida yerleştirmenin yapılabilirliğini incelemek.

YÖNTEM ve GEREÇ: 88 adet yetişkin insan C2 vertebrası kullanıldı. 7 ölçümde intralaminar vida yerleştirmek için vida giriş noktası, seyri ve uzunluğu tanımlandı.

BULGULAR: Sağ C2 laminasının ortalama eni (1/3 üst segment) 2.6 mm (1.2-4.1 mm) idi. Sol C2 laminasının ortalama eni (1/3 üst segment) 2.6 mm (1-4 mm) idi. Sağ C2 laminasının ortalama eni (1/3 orta segment) 4.9 mm (2.6-6.8 mm) idi. Sol C2 laminasının ortalama eni (1/3 orta segment) 4.9mm (2.3-7.6 mm) idi. Sağ C2 laminasının ortalama eni (1/3 alt segment) 5.7 mm (3.3-8.2 mm) idi. Sol C2 laminasının ortalama eni (1/3 alt segment) 5.8 mm (2.2-9.6 mm) idi.

SONUÇ: C2 Lamina 1/3 üst kısmının eni intralaminar vida uygulamaya uygun değildir. Diğer yandan C2 Lamina orta ve alt 1/3 kısmının eni intralaminar vida uygulamaya daha uygundur.

ANAHTAR SÖZCÜKLER: Aksis, C2, İntralaminar vida, Lamina

INTRODUCTION

Recently, the C-2 intralaminar screw technique, originally described as a method for rigid fixation of the C2 by Wright in 2004, has many advantages (5). A technique using crossing screws placed directly into the lamina of C2 was devised. This approach would combine the biomechanical advantages of three-dimensional rigid screw fixation with the safety of attachment only to the dorsal elements (4,5). The C2 intralaminar screw technique may be the safest in terms of the ability to avoid injury to the vertebral artery during C2 screw fixation (3,5). C-2 intralaminar screws can be placed with visual and tactile feedback without fluoroscopy or image guidance. The only drawback to the technique is its requirement for intact and adequately sized lamina (2). Gorek and colleagues demonstrated the biomechanical viability of C2 intralaminar screw fixation. Their results clearly indicate the potential of the intralaminar screw technique to provide stability that is equivalent to methods currently used (1).

The purpose of this study was to determine the precise locations for positioning C2 intralaminar screws so as to avoid structures at risk.

MATERIALS and METHODS

88 complete and undamaged adult Caucasian, dry, C2 spines obtained from four medical schools (Ankara, Erciyes, Osman Gazi and Sutcu Imam) were used. Anatomical measurements of 88 dried C2 spines of undetermined gender and age (Figure 1A,B) were performed by a neurosurgeon who used a Vernier caliper accurate to 0.05 mm. Seven direct morphometric measurements of importance for C2 intralaminar screw placement, relating to the C2 lamina, were obtained. All measurements were obtained bilaterally. C2 lamina was divided into 3 equal parts (1/3 upper segment, 1/3 middle segment, 1/3 lower segment) (Figure 1B). Important angles regarding screw positioning were also measured on the dried specimens.

The entry point of the screws was on the surface of the dorsal arch of C2 with a trajectory aimed through the cancellous bone of the contralateral lamina.

Statistical Analysis

Data were expressed as mean (SD), and range. Analysis was performed for the application of 3.5 mm diameter screws.

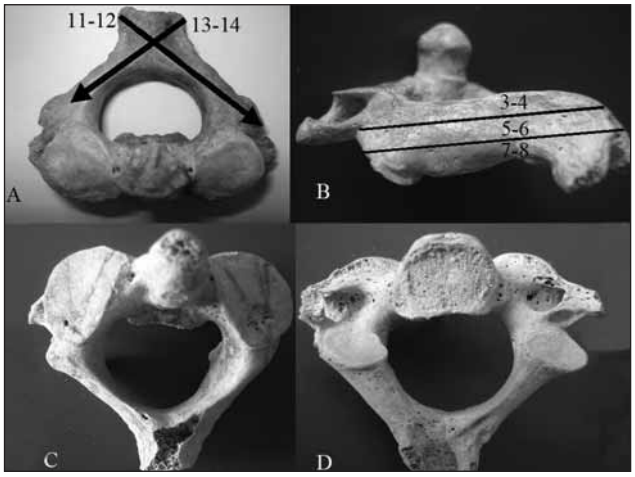

Figure 1: *Measurements of the C2 spine.* ***A****, axial view showing maximal screw length (large arrow).* ***B****, lateral view showing C-2 lamina divided into 3 equal parts (1/3 upper segment, 1/3 middle segment, 1/3 lower segment).* ***C,D*** *axial views showing asymmetry of the C-2 lamina.*

RESULTS

88 paired C2 spines were studied; the mean, standard deviation, and range of each parameter measured for left side and right side as well as for bilateral sides were recorded and listed separately in Table I.

Asymmetry of the C2 lamina was detected in 11 (%12.5) C2 spines (Figure 1 C,D).

The width of the C2 lamina at 1/3 upper segment was mostly between 20-30 mm. The width of the C2 lamina at 1/3 middle segment was mostly between 40-50 mm. The width of the C2 lamina at 1/3 lower segment was mostly greater than 50 mm (Table II).

DISCUSSION

Although no large clinical series of C2 intralaminar screws have yet been published, this technique is gaining popularity for cases in which a C2 laminectomy is not required. Because the entire screw path can be directly visualized or palpated with instruments, the technique seems safe, accessible, and less technically demanding than other C2 screwing techniques. Furthermore, the technique is versatile, allowing the incorporation of constructs extending to the subaxial cervical spine, atlas and occiput (4).

A more recently described intralaminar C2 screw technique may be conceptualized as a variation of the lumbar translaminar facet screw, though the tip of the screw, in this instance, does not cross a joint.

Table I: Measurements (lengths in millimeters, angles in degrees) on dry anatomic specimens of C2 (n:88).

Screw Length	Mean±SD	Minimum	Maximum
1. The height of right C2 lamina	11.4±1.4	8.5	14.3
2. The height of left C2 lamina	11.4±1.3	8.8	14.2
3. The average width of right C2 lamina (1/3 upper segment)	2.6±0.6	1.2	4.1
4. The average width of left C2 lamina (1/3 upper segment)	2.6±0.7	1.0	4.0
5. The average width of right C2 lamina (1/3 middle segment)	4.9±0.9	2.6	6.8
6. The average width of left C2 lamina (1/3 middle segment)	5.0±1.0	2.3	7.6
7. The average width of right C2 lamina (1/3 lower segment)	5.7±1.2	2.5	8.2
8. The average width of left C2 lamina (1/3 lower segment)	5.8±1.4	1.6	9.6
9. Angle between right C2 lamina line and sagittal plane	39.7±1.4	36.0	44.0
10. Angle between left C2 lamina line and sagittal plane	40.9±1.4	38.0	45.0
11. Right screw length with the penetration into the facet articulation	35.4±2.9	28.5	44.1
12. Left screw length with the penetration into the facet articulation	35.7±2.9	23.0	43.6
13. Right screw length without the penetration into the facet articulation	26.4±2.6	20.2	34.2
14. Left screw length without the penetration into the facet articulation	26.5±2.4	21.7	32.6

Table II: Width of the C2 lamina (n:88).

Number of specimens	10–20mm	20–30mm	30–40mm	40-50mm	50-60mm	60-70mm	70-80mm	80-90mm
The average width of right C2 lamina (1/3 upper segment)	8	61	18	1	0	0	0	0
The average width of left C2 lamina (1/3 upper segment)	15	49	24	0	0	0	0	0
The average width of right C2 lamina (1/3 middle segment)	0	3	11	30	29	15	0	0
The average width of left C2 lamina (1/3 middle segment)	0	2	10	31	30	15	0	0
The average width of right C2 lamina (1/3 lower segment)	0	1	3	18	29	24	10	3
The average width of left C2 lamina (1/3 lower segment)	1	1	5	12	27	26	11	5

Using a starting point at the base of the C2 spinous process, a pilot hole is drilled antero-laterally into the contralateral lamina, through which a bone screw is introduced. Initial biomechanical data comparing C1–C2 constructs using intralaminar C2 screw to constructs using C2 pedicle screws yielded no significant differences (1).

C2 screw fixation through the pars or pedicle involves a small but finite risk of vertebral artery injury (3,4). However, C2 intralaminar screws are appealing due to the large size of the C2 lamina, rigid fixation of the axis, and the reduced risk of injury to the vertebral artery. Limited case series have shown good clinical results with this technique and biomechanical studies of C2 laminar screws have recently been published (1,2,3,5,6).

Surgical Techniques. The entry point for screws is at the base of the C2 spinous process. The first screw should enter near the cranial edge and the second screw should be placed starting near the caudal edge in bilateral intralaminar C2 screw usage, to avoid intersecting screw trajectories. The drill is directed

within the contralateral lamina, coursing between the ventral and dorsal cortices. The endpoint is located just caudal to the junction between the pars interarticularis and the lamina. This drill trajectory allows the screw to be placed immediately dorsal to the spinal canal (1).

The structures at greatest risk with posterior screw fixation of C2 lamina are the vertebral artery and the spinal cord. However, the spinal cord is not at risk with correct application of the C2 intralaminar screw fixation technique (3).

Wang et al shows that there is great variability in the size and morphology of the C2 lamina (4). In our study, the minimal laminar diameter was determined to be too small to accommodate a 3.5-mm diameter screw. The average width of right C2 lamina (1/3 upper segment) was 2.6 mm with a range of 1.2 to 4.1 mm. The average width of left C2 lamina (1/3 upper segment) was 2.6 mm with a range of 1 to 4 mm. The average width of right C2 lamina (1/3 middle segment) was 4.9 mm with a range of 2.6 to 6.8 mm. The average width of left C2 lamina (1/3 middle segment) was 5.0 mm with a range of 2.3 to 7.6 mm. The average width of right C2 lamina (1/3 lower segment) was 5.7 mm with a range of 2.5 to 8.2 mm. The average width of left C2 lamina (1/3 lower segment) was 5.8 mm with a range of 1.6 to 9.6 mm. Based on these measurements, the width of the upper one-third of C2 lamina could not accommodate a 3.5 mm screw, on the other hand, the width of the middle and lower one-third of C2 lamina is more convenient for a 3.5 mm screw delivery. This variability must be considered for the sake of patient safety before undertaking C2 intralaminar screw fixation. If not, serious complications may easily occur.

Nakanishi et al and Wright believe that C2 fixation utilizing bilateral, crossing C2 laminar screws represents an advantage to prior reported techniques of C2 fixation due to the elimination of the risk to the vertebral artery during C2 screw placement. This technique is simpler, is not limited by the position of the vertebral artery in the body of C2, and may be applicable to a wider number of patients (3,5).

CONCLUSIONS

C2 intralaminar screw placement is a recently described technique with considerable advantages over traditional fixation methods of the C2. The width of the upper one-third of C2 lamina is not appropriate for the placement of intralaminar screws. On the other hand, the width of the middle and lower one-third of C2 lamina is more convenient for intralaminar screw delivery.

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