Sven Olerud
Claes Olerud

The C1 claw device: a new instrument for C1-C2 fusion

Received: 1 September 1999
Revised: 28 March 2000
Accepted: 5 February 2001
Published online: 25 April 2001
© Springer-Verlag 2001

S. Olerud (✉) · C. Olerud
Department of Orthopaedics,
Uppsala University Hospital,
SE-751 85 Uppsala, Sweden
e-mail: sven.olerud@telia.com,
Fax: +46-18-509427

Abstract A new fixation device for C1-C2 fusion is presented. It consists of a claw construct for the C1 arch that is rigidly attached to C1-C2 transarticular screws to form an instrument that combines anterior and posterior fixation in the same construct. The new device was successfully applied in a case with failed C1-C2 fusion that was initially stabilized with transarticular screws alone,

where the usual posterior wiring was omitted due to a defect of the posterior C1 arch.

Keywords Cervical spine instability · Spine fixation device · Spine surgery · Os odontoideum · C1-C2 fusion

Introduction

Fusion between the C1 and C2 vertebrae due to instability and dislocation has traditionally been performed with the Gallie [4] or the Brooks and Jenkins [1] methods using wire or cable fixation. Both these methods depend on bone blocks put in compression between the C1 arch and the C2 lamina. A new C1-C2 fixation device, the C1 claw device, has been developed, which establishes a rigid fixation between C1 and C2 without the need for bone blocks in compression. With the introduction of this new claw principle for C1 and C2 fixation, anterior dissection of the C1 arch can be avoided and the grafting can be made with bone chips alone. Both these advantages facilitate the surgery. This new method is of special benefit in cases with defects in the C1 arch, as is illustrated by this case report.

The new implant

The implant is made up of two counter-positioned hooks forming a claw that grips the C1 arch firmly. The shaft of the device consists of two semicircular profiles that together make up a 3.5-mm rod. This claw shaft can be connected to a transarticular screw, thus forming a rigid implant that provides both anterior and posterior C1-C2 fixation in a constrained unit (Fig. 1).

Fig. 1 The C1 claw device consists of two counter-positioned hooks, designed to grip the C1 arch, connected to transarticular C1-C2 screws

The claw device is integrated with and constitutes a part of the existing Olerud Cervical Fixation System (Nordopedic AB, Uppsala, Sweden) for posterior cervical spine fixation [9].

Case report

A 55-year-old patient was readmitted to hospital because of a failed C1-C2 fusion. Three months earlier he had been operated with reduction and stabilization for myelopathy due to a forward slip of C1 on C2 secondary to an os odontoideum. The fusion had been stabilized with transarticular screws without adjuvant posterior fixation, because of the presence of a bifid spine at the C1 arch with central defect (Fig. 2).

Abundant cancellous bone graft had been deposited between the stumps of C1 and the arch and posterior process of C2. The ini-

tial clinical course had been favorable, but within a couple of months the patient had experienced upper cervical pain and return of myelopathic symptoms. Radiographic examination revealed a failure of the fusion. The transarticular screws were fractured at the joint level and the slip had recurred. Most of the bone graft was resorbed (Fig. 3).

At re-operation, the C1-C2 articulation was stabilized with the new device. The posterior parts of the transarticular screws were

Fig. 2 Axial computed tomographic (CT) image of C1. Note the central defect of the posterior arch of C1

Fig. 3 The initial attempt at C1-C2 fusion was performed with transarticular screws, but without adjuvant posterior fixation due to the bifid spine of C1. At 2 months, the screws had fractured at the facet joint and the fusion had failed

Fig. 4 The applied construct mounted on a saw bone. The transverse bar prevents the claws from dislocating into the defect of the C1 arch

Fig. 5 One-year radiograph revealing a good fusion healing in a reduced position

removed from C2, whereas tips buried in C1 were left in place. The C1 and C2 vertebrae were realigned and new transarticular C1-C2 screws were inserted. There were no problems inserting the new screws next to the retained tips of the old ones in C1. The lateral stumps of the posterior C1 arch were dissected free, and a C1 claw device was attached to each side. The claws were pressed laterally on the stumps and a transverse rod was mounted directly below the claws to secure their positions, preventing the claws from dislodging into the central defect of C1 (Fig. 4).

Autologous cancellous bone graft was added to complete the fusion between the two vertebrae. The patient used a Philadelphia collar for 3 months.

The postoperative course was uneventful. Direct postoperative radiographs revealed an acceptable alignment between C1 and C2. At 5 months, the patient was doing fine clinically. The radiographs showed a good progression of fusion healing in an unchanged position. At 12 months the patient was pain free, most of the myelopathy symptoms had resolved, and the fusion was consolidated (Fig. 5).

Discussion

In order to achieve a successful C1-C2 fusion, a mechanical stability between the vertebrae combined with bone grafting is necessary. The Gallie [4] and the Brooks and Jenkins [1] techniques achieve this stability with structural bone blocks fixed in compression with wire or cable. With only posterior wiring, these techniques are not effective against rotatory forces, and a high failure rate has followed. In order to increase the stability, Magerl and Seeman [8] added transarticular screws through the C1-C2 joints. The good stability achieved by combining transarticular screws with posterior wiring was documented by Grob et al. [5], and also led to a higher fusion rate [2].

However, in cases with a defective posterior C1 arch (e.g. fracture or bifid spine), the wiring technique according to Gallie can not be applied. The Brooks technique may be applicable, but it is considered risky to place cerclage wire under the C2 arch, and there is also the risk of the wires dislodging into the defect of C1. Other options include:

1. One can omit the posterior wiring technique altogether and rely on transarticular screws only [7].

2. The transarticular screws can be combined with posterior screws into the C1 "pedicles" together with stabilizing against C2 [3].
3. The fusion can be extended to the occiput.

The first technique has biomechanical drawbacks, although Jeanneret and Magerl [7] showed good results in a few cases. The screws pass close to the motion axis of the facet joints, which makes them effective against translatory and lateral bending forces. However, extension-flexion is poorly controlled and motion in this plane will put a bending moment on the screws, with risk of metal fatigue at the facet joint, as in our patient. Attaching a bone graft with screws driven into the C1 arch stumps may be a good alternative, but the technique must be considered experimental, and many surgeons may hesitate to do this. Furthermore, as the bone graft has no secured attachment to C2, this technique too will control extension-flexion poorly, with subsequent risk for screw fatigue. The third alternative is also associated with significant drawbacks; an extended fusion has more healing disturbances and causes significant loss of mobility. There is also a risk of rapid degeneration of the first mobile segment below the fusion.

With the new C1 claw device, however, the benefits of a short fusion can still be enjoyed in spite of local anatomical difficulties. The C1 arch can be securely caught with the claws of the device, even if the central portion of the arch is missing. The rigid fixation to the transarticular screws gives both posterior and anterior fixation in the same instrument. This allows reliable stabilization against motion in all six degrees of freedom: antero-posterior slip as well as extension-flexion; lateral slip as well as lateral bending; and axial translation as well as rotation [6].

The fixation instrument results in sufficient stability in itself, without relying on the integrity of a solid block of bone, thus allowing bone chips to be used as graft material. This may be very advantageous, as most C1-C2 fusions are performed in rheumatoid arthritis patients or elderly patients with odontoid fractures, where the bone at the iliac crest may be of inferior quality due to osteoporosis.

References

1. Brooks AL, Jenkins EB (1978) Atlanto-axial arthrodesis by the wedge compression method. *J Bone Joint Surg Am* 60:279-284
2. Dickman CA, Sonntag VK (1998) Posterior C1-C2 transarticular screw fixation for atlantoaxial arthrodesis. *Neurosurgery* 43:275-280
3. Floyd T, Grob D (1999) Translaminar screws of the atlas. *Cervical Spine Research Society 27th Annual Meeting*, December 16-18, Seattle
4. Gallie WE (1939) Fractures and dislocations of the cervical spine. *Am J Surg* 46:495-501
5. Grob D, Crisco JJ 3rd, Panjabi MM, Wang P, Dvorak J (1992) Biomechanical evaluation of four different posterior atlantoaxial fixation techniques. *Spine* 17:480-490
6. Henriques T, Cunningham BW, Shimamoto N, Olerud C, Lee GA, Larsson S, McAfee PA (1999) Biomechanical comparison of five different atlanto-axial posterior fixation techniques. *Cervical Spine Research Society 27th Annual Meeting*, December 16-18, Seattle
7. Jeanneret B, Magerl F (1992) Primary posterior fusion C1/2 in odontoid fractures: indications, technique, and results of transarticular screw fixation. *J Spinal Disord* 5:464-475
8. Magerl F, Seeman PS (1987) Stable posterior fusion of the atlas and axis by transarticular screw fixation. In: Kehr P, Weidner A (eds) *The cervical spine*. Springer, New York Vienna, pp 322-327
9. Olerud C, Lind B, Sahlstedt B (1999) The Olerud cervical fixation system; a study of safety and efficacy. *Uppsala J Med Sci* 104:131-143