Abstract

In 2000 a cannulated screw stabilization system for posterior cervical instrumentation was introduced in our department for use in complex cervical fixation procedures. A special feature of the system is the use of thin Kirschner wires for drilling the screw paths and then placing the self-drilling, cannulated screws securely over the wires. Percutaneous application of C1–C2 transarticular screws is possible through tubes. An optional "atlas-claw" provides additional stability in cases of C1–C2 stabilization. 17 patients (10 female, 7 male, mean age 60 years) with complex cervical disorders and instability of different origin were stabilized using the Neon System (Ulrich Co., Ulm, Germany). Pathology included atlantoaxial instability based on rheumatoid arthritis (n=12), odontoid fracture (n=4) and os odontoideum mobile (n=1). Computed navigation (STN 4.0, Zeiss or vector vision spine, brain lab) was used in 14 cases. Transarticular C1–C2 screw fixation was performed in 14 cases (4 patients with direct C1 massa lateralis screw fixation), cranio cervical fixation (C0–C2/C3) was done in 3 patients. Percutaneous application of the C1–C2 screws was used in 7 patients. Atlas claws were applied in 8 patients. There was one medial perforation of a C2 pedicle wall and one malposition of the screw in C2 without reaching the lateral mass of C1. After a mean follow-up of 9 months there were no hardware failures and stable fusion in those cases followed after 12 months or more. Clinical results were excellent or good in 14/16 patients. Cannulated screws are an effective alternative in complex stabilization procedures of the cervical spine. The presented system is technically comfortable and allows safe percutaneous screw application as well as inclusion of computed navigation with high accuracy.

Key words

Transarticular screw fixation · atlantoaxial instability · percutaneous screw application · cannulated screw · computer assisted spine surgery

Introduction

Transarticular atlantoaxial screw fixation is well accepted as the most stable and efficient method to treat atlantoaxial instability [1–3]. The procedure is demanding because of the associated risks owing to the complex anatomy of the region. Vertebral artery injury and/or damage to the spinal cord are of most concern. To minimize these risks, computer-assisted surgery has been introduced recently and has been proven to effectively reduce screw malplacements [4–9].

Most systems used for this surgery require drilling of the screw paths prior to screw placement. Using a 2.3–2.5 mm drill bit, therefore, is the most delicate part of the procedure. As previously established with anterior odontoid screw fixation, usage of cannulated screws that are placed over thin Kirschner wires with which the screw path was drilled appears as an effective additional tool to make the procedure safer [10].
Another problem of C1–C2 stabilization is the necessity of establishing a very steep angle (60 to 70 degrees) with respect to the entrance point of the screw. If done as an open procedure, extensive neck muscle dissection is needed to obtain this angle. McGuire and Harkey introduced the percutaneous application technique in 1995 and its use has increased since then among many spine surgeons.

In this report we detail our experience with a cannulated screw system that incorporates all these recent developments. Thus, optimal risk reduction in this particular procedure is achieved with less tissue damage.

Material and Methods

Surgical system

The Neon® System (Ulrich, Ulm, Germany) consists of a variety of cannulated screws, either self-drilling or self-tapping, with a diameter of 4 mm and different lengths. The central opening allows use of a 1.5 mm Kirschner wire to perform the wire drilling in the case of transarticular C1–C2 screw placement or to place a Kirschner wire into the screw path after being drilled with a conventional drill burr in cases of lateral mass screw placement. Recently, 3.5 mm screws without cannulation have also been introduced to make the system more versatile in cases of small lateral masses in the subaxial spine. The system is created for dorsal instrumented stabilization procedures from the occiput down to Th 9.

To place screws percutaneously, metal tubes have been created to tunnel the percutaneous path down to the entry point of the screws in an adequate angle. Special Kirschner wires are provided with standardized lengths and markers to determine the screw lengths after wire placement. The drill guide allows attachment of the navigational reference devices of various navigation systems to perform computer-guided drilling (Figs. 1–6).

Utilizing a special locking system, rods or rod-plate constructions are attachable as well as an optional atlas claw for fixing the posterior atlas ring to the construct.

Patients

Between January 2000 and October 2003, 17 patients (10 female, 7 male, mean age 60, range 19–81 years) with complex cervical disorders and instability of different origin were stabilized using the Neon System (Ulrich Co., Ulm, Germany). Pathology included atlantoaxial instability based on rheumatoid arthritis (n = 12), odontoid fracture (n = 4) and os odontoideum mobile (n = 1).

Neurological deficits were present in only two patients with rheumatoid arthritis who presented a mild myelopathy. In all other cases pain deriving from instability was the main presenting complaint. Computed navigation (STN 4.0, Zeiss or vector vision spine, brain lab) was used in 14 cases.

Follow-up included clinical examination and radiological investigations postoperatively and at 3 months as well as after one
Operative site after percutaneous image-guided placement of the transarticular Kirschner wires. The reference clamp of the image guidance system is still in place.

Photograph showing a 40-mm cannulated self-drilling and self-tapping transarticular screw of the Neon® system fixed in a screwdriver and placed over the Kirschner wire.

Postoperative lateral X-ray after percutaneous image-guided transarticular C1-C2 screw fixation in a patient with rheumatoid arthritis and odontoid destruction. Correct placement of the screws was confirmed by CT. Note the atlas clamp fixing the posterior atlas ring to the construct.

Postoperative lateral X-ray after percutaneous image-guided transarticular C1-C2 screw fixation in a patient with rheumatoid arthritis and odontoid destruction. Correct placement of the screws was confirmed by CT. Note the atlas clamp fixing the posterior atlas ring to the construct.

Results

Transarticular C1-C2 screw fixation was performed in 14 cases, craniocervical fixation (C0-C2/C3 or C4) was done in 3 patients. In 4 patients we performed direct C1 massa lateralis screw fixation at one side because of a high-riding vertebral artery and inability to create a transarticular screw path in C1-C2. Percutaneous application of the C1-C2 screws was used in 7 patients. In all other cases a conventional open procedure was chosen either because of very thick necks (4 patients) or the necessity for a more generous dissection to place longer constructs or decompress the spinal cord (6 patients). Atlas claws were applied in 8 patients. Additional posterior bone graft placement was performed in all cases to allow bony fusion.

One patient died two months after the procedure due to causes not related to the surgery. There was one medial perforation of a C2 pedicle wall and one malposition of the screw in C2 without reaching the lateral mass of C1. After a mean follow-up of 9 months there were no hardware failures and stable fusion was seen in those cases followed for 12 months or more (8 patients). Clinical results were excellent or good in 14/16 patients. No neurological deterioration was observed.

We also noted that continuous intake of analgesics after operation was quite low and limited to three to five days. Thereafter analgesics were only needed occasionally. Although there is no meaningful statistical analysis possible with such a small patient group, there was a trend toward less time with continuous analgesic medication in the group of percutaneously operated patients (see Fig. 7).

Discussion

Cannulated screws for atlantoaxial stabilization have only rarely been reported to date. Dickman et al. were the first to publish their initial experience in 1995 [10]. Haid et al. reported a large series including 75 patients with various pathologies in 2001. These authors used cannulated screws but did not utilize additional image guidance [3]. Wigfield et al. have reported the largest series using percutaneous image-guided screw placement with cannulated screws in 2001, including 46 patients, but it is not known whether the system they used was specially created for this procedure or whether cannulated odontoid screws were used [6].
open procedure. Due to low patient numbers in this preliminary series there is no meaningful statistical evaluation possible, but a trend is present for less need of analgesic medication in the percutaneous procedure group.

One major advantage of using Kirschner wires and cannulated screws instead of conventional drill burrs is that the amount of bone that is drilled away is reduced. This creates in our view a better screw anchorage within the bone with a higher pull-out resistance. A second advantage is that in case of drilling a "wrong" path one can reposition the wire and proceed again. This is often impossible after having drilled a path with a 2.3 or 2.5 mm drill burr because of the lack of bone mass.

As the drilling is the most important surgical step with atlantoaxial screw placement, computer-assisted drilling is the key to correct screw placement. Screw placement itself must not necessarily be performed with image guidance in this setting.

With the system presented here, the drill guide is referenced to the navigation system and allows an "online" monitoring of the progress of the drill wire. One has to bear in mind, however, that only C2 is navigated with this method and X-ray control is still mandatory. It is also indispensable to assure that the placed drill wire is not advanced anteriorly when the cannulated screws are applied over the wires. The tubes that are provided allow a reliable computer-assisted drilling via the percutaneous route.

The additional placement of atlas claws provides an excellent stabilization, as already found by Richter et al. in their biomechanical testing of different methods and instrumentations [1,12].

In one of our cases the C1–C2 screw not reach the C1 lateral mass and was therefore only anchored within C2. Although others have described sufficient stability of such a construct with only one transarticular screw and the added bone graft dorsally, we feel that in such a situation the atlas claw is also helpful because it provides at least a dorsal stabilizing effect by its connection between C2 and the posterior atlas ring. In this case there was excellent healing and fusion could be demonstrated after 12 months.

Concerning the relationship between pain reduction and the less traumatic approach our small patient group seems to confirm that postoperative pain is acceptable and of short duration. Blauth et al. have also demonstrated in their comparative study between open versus percutaneous transarticular screw placement that the percutaneous way resulted in lower pain scores in their patients [2].

We also believe that less dissection of the neck musculature does help prevent postoperative stress on the adjacent mobile segments because of preserved muscle forces. This will eventually result in a more pain-free healing and better functional result after the occurrence of bony fusion.

**Conclusions**

The recent developments in instrumentation and techniques for transarticular C1–C2 screw fixation have made this demanding procedure safer and more feasible. Besides the increased safety due to the use of cannulated screws and the implementation of image guidance, percutaneous screw application is now possible without loss of accuracy.

The reduction of soft tissue trauma, although not possible in all cases, is considerable and clearly correlated with a shorter recovery time for patients.

Further developments in image guided surgery, e.g., the application of 3D-fluoroscopy, will eventually further improve the current technical possibilities in terms of cost and time saving.

**References**