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Clinical Article

Anterior Screw Fixation using Herbert Screw for Type II Odontoid Process Fractures

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Objective : Anterior screw fixation provides the best anatomical and functional results for type II odontoid process fracture (type II-A, II-N, and II-P) with intact transverse ligament. The purpose of this study is to evaluate the usefulness of the 4.5mm diameter, cannulated Herbert screw in anterior screw fixation.

Methods : From Jan. 2003 to Feb. 2004, consecutive 10cases of type II odontoid process fractures were treated with anterior screw fixation using a Herbert screw. The Herbert screw has double threads, with different pitches on the distal and proximal ends. It has no head, so it can be inserted through articular cartilage and buried below bone surface. It was originally developed for treating scaphoid fractures.

Results : There were 8male and 2female patients whose ages ranged from 15 to 67years (mean 42.1years). The fracture type was type II-A in 4patients, II-N in 3patients, and II-P in 3patients. The fracture line was oblique downward and backward in 6cases, oblique downward and forward in 1case, and horizontal in 3cases. The range of follow-up was 5 to 18months (mean 12months). Bone fusions were achieved in all cases without any instrumental failures or postoperative complications.

Conclusion : The Herbert screw is very useful in anterior fixation for type II odontoid process fracture. This series showed successful results also in type II-A odontoid fracture when treated with the Herbert screw, but further more studies are required.

KEY WORDS : Herbert screw · Atlanto-axial instability · Type II odontoid process fracture · Anterior screw fixation.

Introduction

Anterior screw fixation provides the best anatomical and functional results for type II odontoid process fractures (type II-A, type II-N, and type II-P) with intact transverse ligament, and is considered as a treatment of choice for type II-P fractures[2,8,17]. Recently, its simple procedures and satisfactory results brought popularity for treatment even in type II-A and type II-N fractures. Several kinds of screws are available for the procedure. One or two, 3.5 or 4.0mm in diameter, titanium or stainless, cannulated or non-cannulated, cancellous and half threaded screws are usually used[1,4,8,12,13,16,18-21]. The author has been recently using a Herbert screw in anterior odontoid screw fixation. To the best of our knowledge, this is the first study describing anterior odontoid screw fixation using a Herbert screw.

The purpose of this study is to evaluate the usefulness of Herbert screw in anterior odontoid screw fixation, which has double threads with different pitches on the distal and proximal ends and has no head.

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Materials and Methods

Materials

Between April 1995 and February 2004, 38 patients with type II odontoid process fractures were treated with anterior screw fixation. The Herbert screw was used in recent 10 consecutive patients from January 2003 to February 2004.

Herbert screw

The Herbert screw has double threads, with different pitches on the distal and proximal ends. Because of this pitch differential, the leading threads penetrate the bone faster than the trailing threads, which reduces the gap and compresses the fractured fragments as the screw is being inserted. This specialized screw has no head, so it can be inserted through articular cartilage and buried below the bone surface. Thus, the Herbert implant is ideal for intra-articular use because nothing protrudes above the bone surface to interfere with articulation or soft tissue. It was originally developed for the use in treating scaphoid fractures. The expanded system is currently used in a wide range of small bone fractures and intra-articular procedures,

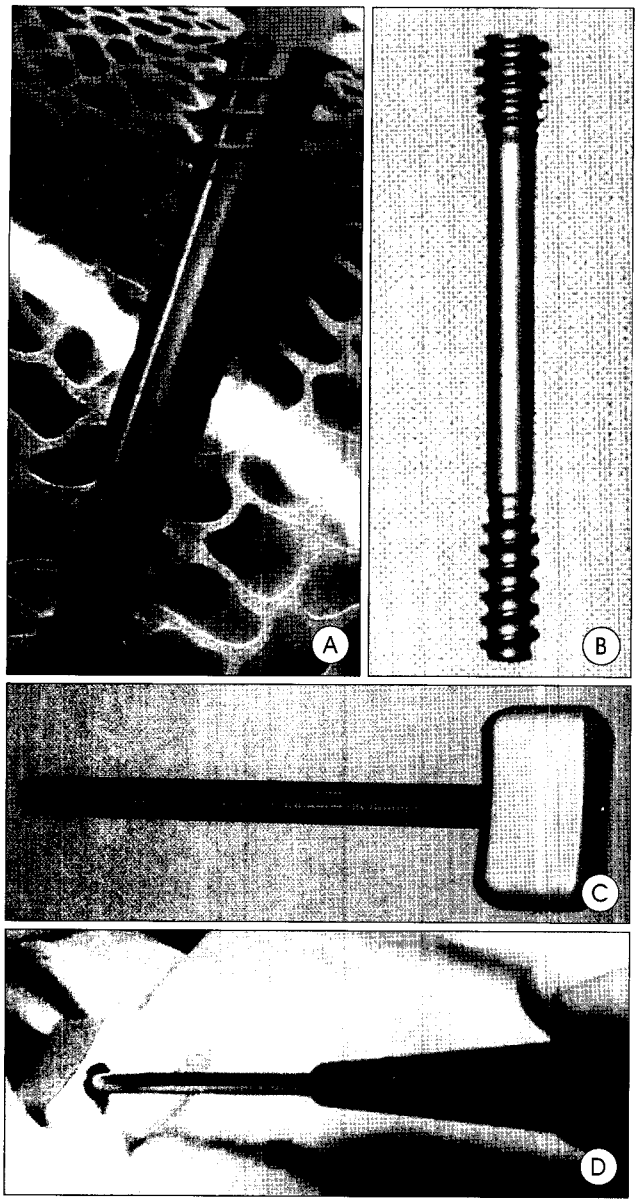

Fig. 1. The Herbert screw has double threads, with different pitches on the distal and proximal ends. The leading threads penetrate bone faster than the trailing threads, which reduces the gap and compresses the fractured fragments as the screw is being inserted. It has no head, and can be buried below the bone surface without disturbing any articular motion(A). A 4.5mm diameter Herbert screw and an outer sheath are shown(B and C). The operation procedures are all performed inside the outer sheath(D).

and the author tried this system in anterior odontoid screw fixation. This Implant is manufactured from *Tivanium*® Ti-6Al-4V Alloy (Zimmer) which provides excellent strength and biocompatibility (Fig. 1).

Operative technique

The patient was placed supine on the operating table. Halter or Gardner-Wells traction was used to achieve maximal reduction and to hold the head immobile. Nasotracheal intubation was done. The mouth was kept open with a radiolucent gauze. The fluoroscopic angle, the patient position, and operating table level were adjusted for adequate visualization of open-mouth anterior-posterior view as well as lateral view. A 2.5cm transverse skin incision was made at C3-4 intervertebral space level. Blunt dissection was made to expose the anterior surface of the cervical vertebra by separating planes between the carotid artery laterally and the esophagus and trachea medially. Then the antero-inferior edge of the C2 vertebral body was exposed by proceeding rostrally along the anterior longitudinal ligament. The anterior longitudinal ligament was dissected at the antero-inferior edge of the C2 vertebral body. The outer sheath was positioned on the antero-inferior lip of C2 at the exact entrance site planned for the fixation system. No retraction was required because the procedures were all performed inside the outer sheath. Through the outer sheath, a 2mm diameter K-wire was introduced to postero-superior part of dens through C2 body, fracture site, and the cortex of dens with confirmation of correct position of the wire on AP and lateral views of fluoroscopic image. The length of the screw was determined by depth gauge, and tapping was done with 3.5mm tap. Then, a 4.5mm diameter Herbert screw was inserted over the K-wire until the leading threads penetrated into the cortical part of upper dens, and the trailing threads were buried below the bone surface of C2 body. After the screw fixation, stability was confirmed by flexion and extension of cervical vertebra under fluoroscopy, and no mobility should be detected between dens and C2 body or screw. The patients were requested to wear Philadelphia neck brace and ambulated from the day after the operation. At 3months after the operation, simple cervical radiographs and computed tomography were checked to ensure bone fusion.

Results

There were 8male and 2female patients with type II odontoid process fracture whose ages ranged from 15 to 67years (mean 42.1years). The fracture type was type II-A in 4 patients, type II-N in 3 patients, and type II-P in 3 patients. In type II-A group, the displacement was 3mm, 7mm, 8mm, and 15mm respectively, and in type II-P group, 3mm, 7mm, and 11mm respectively. In type II-N group, the displacement ranged from 0mm to 1mm. The fracture line was oblique downward and backward in 6cases, oblique downward and forward in 1case, and horizontal in 3cases. Single 4.5mm diameter Herbert screw was used for odontoid fixation in each

Table 1. Clinical summary of cases

No.	Age/Sex	Cause	Sx.& Sign	Type of odontoid fracture	D/P	Fracture line	Outcome
1	49/M	TA	Neck pain	II-N	1mm	Downward & Backward	Good
2	64/F	Fall down	Neck pain	II-A	3mm	Horizontal	Good
3	44/M	TA	Quadriparesis	II-A	8mm	Downward & Forward	Good
4	37/M	TA	Neck pain	II-N	0mm	Downward & Backward	Good
5	61/M	TA	Neck pain	II-A	15mm	Horizontal	Good
6	67/M	TA	Neck pain	II-P	7mm	Downward & Backward	Good
7	44/F	TA	Neck pain	II-N	0mm	Downward & Backward	Good
8	21/M	TA	Neck pain	II-P	3mm	Downward & Backward	Good
9	15/M	Slip down	Quadriparesis	II-P	11mm	Downward & Backward	Good
10	19/M	TA	Neck pain	II-A	7mm	Horizontal	Good

TA : traffic accident, D/P : displacement, M : male, F : female, II-N : no displacement of odontoid process II-A : anterior displacement of odontoid process II-B : posterior displacement of odontoid process

case. In all 10 cases, bone fusions were achieved without any instrumental failures or postoperative complications (Table 1).

Discussion

Because various methods of treatments exist for type II and III odontoid process fractures, considerable controversy exists regarding the best method for stabilizing these fractures[14,15]. Initial treatment has relied primarily on immobilization by using a rigid orthosis such as a halo vest or a Minerva jacket. Reported success with such immobilization has varied widely from 37 to 75%. Relatively high failure rate associated with this method of treatment have led several authors to attempt operative treatment of C1-2 posterior fusion as a primary treatment[1,5-9,13,21,22]. The results of such studies have suggested that high degree of dens dislocation (>4~6mm), increasing age (>40~65years), type II-P fractures, prolonged traction, and inadequate treatment due to delayed diagnosis would predict lower rates of fracture union, thus patients fitting into one or more of these categories are considered as surgical candidates[9]. However, such C1-2 posterior stabilization method results in loss of rotatory movement of head and neck by more than 50%. To overcome such limitation, anterior screw fixation have been attempted for type II-P. Posterior stabilization have been performed for type II-A since anterior stabilization seems to be inadequate for this type of fractures. Currently, anterior stabilization is attempted even for type II-A for preservation of normal C1-2 rotatory motion. Several kinds of screws are available for anterior screw fixation. One or two, 3.5 or 4.0mm in diameter, titanium or stainless, cannulated or non-cannulated, cancellous or cortical, and half threaded or full-threaded screws are usually used (Fig. 2)[1,4,8,12,13,16,18-21]. There has been controversy regarding the number of screw for fixation. In the past, two-screw construct was preferred because it seemed to offer the theoretical advantage of increased strength over one-screw construct. However, no increased strength against bending movement or rotation have been shown in the biomechanical studies, and also no differences have been proven in the overall rate of bone fusion. Subach et al used only one-screw construct because the second screw increased additional risk and no biomechanical advantages were proven[21]. The author used two-screw construct previously but now use only one-screw construct. Screws with 3.5mm diameter were used for previous two-screw construct, and 4.0mm diameter screw for one-screw construct[13]. The cannulated screw can be inserted over the guide wire and this makes the procedure easy and convenient.

The author once had a problem with screw loosening during an operation using a 4.0mm diameter, titanium, cannulated, half-threaded screw. A screw of larger diameter was required, and 4.5mm diameter Herbert screw was first attempted for anterior odontoid screw fixation.

The Herbert screw is manufactured from *Tivanium®* Ti-6Al-4V(Zimmer) Alloy which provides excellent strength and biocompatibility. The Herbert screw has double threads, with different pitches on the distal and proximal ends. Because of this pitch differential, the leading threads penetrate the bone faster than the trailing threads, which reduces the gap and compresses the fractured fragments as the screw is being inserted. This specialized screw has no head, so it can be inserted through articular cartilage and buried below the bone

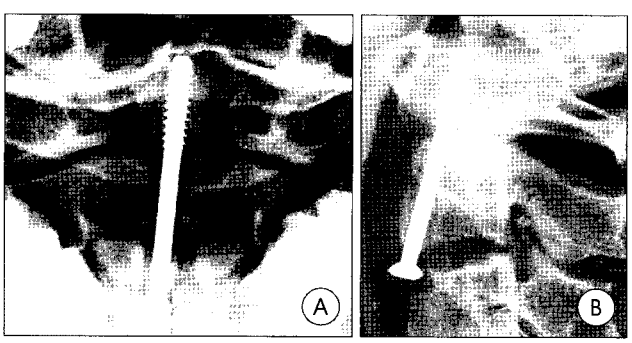

Fig. 2. Anterior screw fixation was performed with routinely used single cannulated screw. Postoperative open-mouth(A) and lateral view(B) show the protruded screw head disturbing anterosuperior portion of C2-3 joint.

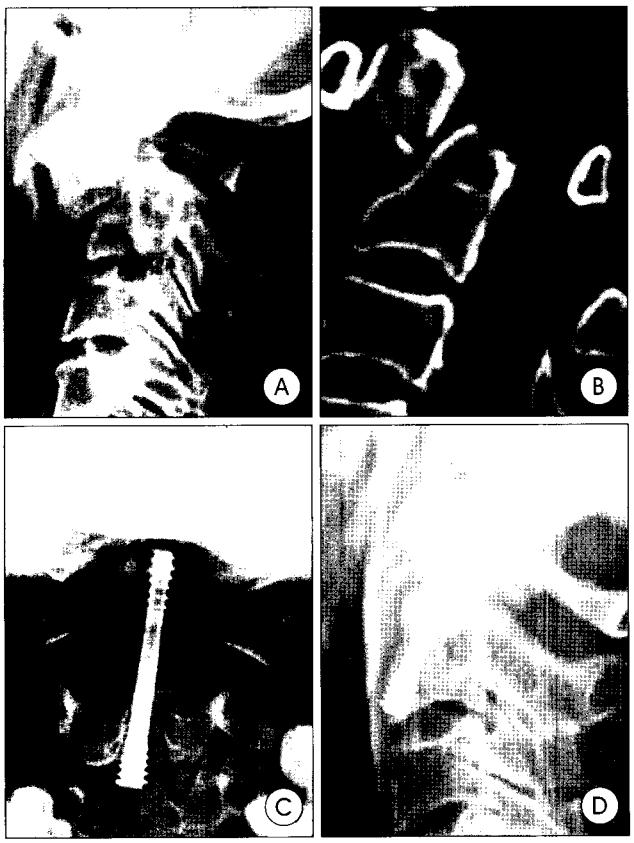

Fig. 3. A 4.5mm cannulated Herbert screw is used in anterior screw fixation of type II odontoid process fracture. Preoperative lateral view of plain cervical X-ray(A) and Sagittal reconstruction view of computed tomography(B) showing severe anterior displacement of fractured odontoid process with a horizontal fracture line. Postoperative open-mouth(C) and lateral view(D) showing excellent anterior odontoid fixation.

surface. Thus, the Herbert implant is ideal for intra-articular use because nothing protrudes above the bone surface to interfere with articulation or soft tissue. It was originally developed for the use in treating scaphoid fractures. The expanded system is currently used in a wide range of small bone fractures and intra-articular procedures, and the author tried this system in anterior odontoid screw fixation (Fig. 1).

The skin incision is generally made at C5-6 level[1]. The author first started at C5-6 level, then changed to C4-5 level[13], and now uses C3-4 level for skin incision. This made the working distance up to C2-3 level much shorter, and the procedure became more convenient.

In general, burr drilling is required at the upper part of C3 to make place for the screw head (Fig. 2). The Herbert screw does not have a head and no additional procedures are required to make place for screw head.

Morandi et al emphasized on the use of protective tool to prevent soft tissue injury while drilling[18]. Hott et al reported a new retractor system for same purpose[11]. However, no retraction was required when using this instrumentation because the procedures were all performed inside the outer sheath (Fig. 1). Minimal invasive endoscopic surgery for anterior odontoid screw fixation is reported in the recent literature[10], but our method of surgery, making only 2.5cm of skin incision, can also be regarded as a minimal invasive surgery.

When inserting a 4.5mm Herbert screw after tapping with 3.5mm tapper over the K-wire, some degree of resistance may occur almost at the end near the point when the trailing threads enter the bone. This is mostly due to the leading threads when penetrating the cortical part of upper dens, not the trailing threads. Sufficient drilling of the cortical part of upper dens allows easier insertion of the screw.

Roy-Camille divided the fractures into 3types according to the direction of fracture line; oblique downward and forward, oblique downward and backward, and horizontal. Latter two types were treated with anterior screw fixation by Morandi et al[18]. Anterior screw fixation is regarded as a treatment of choice for type II-P odontoid fractures[1,3,4,6,8,13,20]. Most authors regarded type II and shallow type III odontoid fractures with oblique downward and backward or horizontal fracture lines as indications of anterior fixation, and the fractures with oblique downward and forward fracture lines as a contraindication of the procedure. The rationale for this concept is based on the fact that the screw should be perpendicular to the fracture line to maintain the fixation mechanically firm and rigid, and it is impossible in the case with oblique downward and forward fracture line to make fracture line perpendicular to anterior screw fixation. Kim et al reported several failed cases of type II-A odontoid fractures with oblique downward and forward fracture line when treated with anterior screw fixation using a cannulated, cancellous, half-threaded screw[13].

In our series, the author had 4 successful cases of type II-A odontoid fractures (1 case of oblique downward and forward, and 3 cases of horizontal) when treated with the Herbert screw. Especially in the case 5, the patient had an anterior displacement of 15mm, but had a satisfactory outcome with good bone fusion (Fig. 3). It suggests a possibility of good outcome in type II-A odontoid fractures when treated with anterior screw fixation using the Herbert screw, and more cases are to be evaluated for further study.

Conclusion

The Herbert screw is very useful in anterior fixation of type II odontoid process fracture. This screw has a double threads, with a different pitch on the distal and proximal ends. Due to a unique design, odontoid fracure reduction and compression are

combined to provide rigid internal fixation. The Herbert screw provides significant advantages over fixation techniques using conventional bone screws. This series showed successful results also in type II-A odontoid fractures when treated with the Herbert screw, but further more studies are required.

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