ELSEVIER

CrossMark

The Spine Journal 15 (2015) 2271–2281

THE SPINE JOURNAL

Review Article

Posterior atlantoaxial fixation: a review of all techniques

Da-Geng Huang, MD, Ding-Jun Hao, MD*, Bao-Rong He, MD, Qi-Ning Wu, MD, Tuan-Jiang Liu, MD, Xiao-Dong Wang, MD, Hua Guo, MD, Xiang-Yi Fang, MD

Department of Spine Surgery, Honghui Hospital, Xi'an Jiaotong University Health Science Center, No. 76 Nanguo Rd, Xi'an, Shaanxi, 710054, China

Received 11 December 2014; revised 24 April 2015; accepted 1 July 2015

Abstract

BACKGROUND CONTEXT: Posterior atlantoaxial fixation is an effective treatment for atlantoaxial instability. Great advancements on posterior atlantoaxial fixation techniques have been made in the past decades. However, there is no article reviewing all the posterior atlantoaxial fixation techniques yet.

PURPOSE: The aim was to review the evolution and advancements of posterior atlantoaxial fixation.

STUDY DESIGN: This was a literature review.

METHODS: The application of all posterior fixation techniques in atlantoaxial stabilization, including wiring techniques, interlaminar clamp fixation, transarticular fixation, screw-plate systems, screw-rod systems, and hook-screw systems, are reviewed and discussed. Recent advancements on the novel technique of atlantoaxial fixation are described. The combination of the C1 and C2 screws in screw-rod systems are described in detail.

RESULTS: All fixation techniques are useful. The screw-rod system appears to be the most popular approach. However, many novel or modified fixation methods have been introduced in recent years.

CONCLUSIONS: Great advancements on posterior atlantoaxial fixation techniques have been made in the past decades. The wiring technique and interlaminar clamps technique have fallen out of favor because of the development of newer and superior fixation techniques. The C1–C2 transarticular screw technique may remain the gold standard for atlantoaxial fusion, whereas screw-rod systems, especially the C1 pedicle screw combined with C2 pedicle/pars screw fixation, have become the most popular fixation techniques. Hook-screw systems are alternatives for atlantoaxial fixation.

Keywords: Atlantoaxial instability; Posterior fixation; Clamp; Screw fixation; Wires; Lateral mass screw; Pedicle screw

Introduction

The atlantoaxial junction, including the atlas (C1) and the axis (C2), is a highly specialized area of the spine. The atlas and the axis are quite different from other vertebrae, and very complex anatomically. Atlantoaxial instability is extremely dangerous and can be caused by trauma, congenital malformation, tumor, or inflammation. Posterior atlantoaxial fixation is an effective treatment for atlantoaxial instability.

Since Gallie [1] first reported the use of sublaminar wires for atlantoaxial fixation in 1939, great advancements have been made in posterior atlantoaxial stabilization techniques, especially in recent years. In the present study, we review all posterior atlantoaxial fixation techniques, including traditional, popular, and novel techniques. Posterior atlantoaxial fixation techniques are categorized into six main types: wiring, interlaminar clamps, atlantoaxial transarticular screws, screw-plate system fixation, screw-rod system fixation, and hook-screw system fixation techniques.

FDA device/drug status: Not applicable.

Author disclosures: ***D-GH:*** Nothing to disclose. ***D-JH:*** Nothing to disclose. ***B-RH:*** Nothing to disclose. ***Q-NW:*** Nothing to disclose. ***T-JL:*** Nothing to disclose. ***X-DW:*** Nothing to disclose. ***HG:*** Nothing to disclose. ***X-YF:*** Nothing to disclose.

* Corresponding author. Department of Spine Surgery, Honghui Hospital, Xi'an Jiaotong University Health Science Center, No. 76 Nanguo Rd, Xi'an, Shaanxi, 710054, China. Tel./fax: (86) 29 33571457.

E-mail address: hdgrichard@sina.com (D.-J. Hao)

http://dx.doi.org/10.1016/j.spinee.2015.07.008

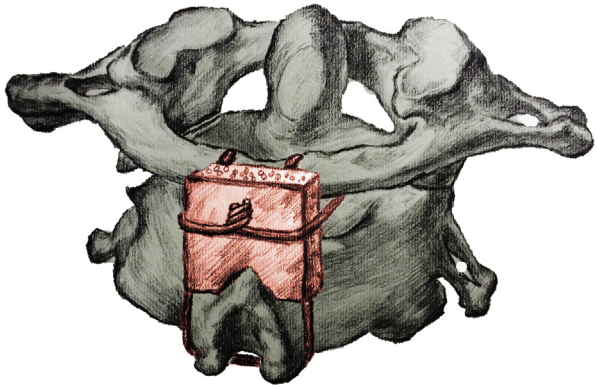

Fig. 1. Gallie technique for atlantoaxial fusion.

Wiring techniques

Posterior wiring was the initial atlantoaxial fixation technique. In 1939, Gallie [1] first described the use of sublaminar wires for atlantoaxial fixation, also called Gallie fusion (Fig. 1). This is the simplest posterior atlantoaxial fusion technique, but also uses the poorest quality biomechanical instrumentation [2]. The inferior stabilization during rotation results in a very high nonunion rate (25%) [3].

In 1978, the Brooks-Jenkins technique was reported [4]. In this technique, two separate iliac crest autografts are placed between C1 and C2 and wrapped with wires (Fig. 2). Brooks-Jenkins fixation provides more rotational stability than Gallie fixation [5], while providing similar stability in flexion and extension [6]. A fusion rate of 93% was reported in the study by Brooks and Jenkins [4]. However, the passage of bilateral sublaminar cables under both the C1 and C2 lamina causes a higher potential rate of spinal cord injury.

In 1991, Dickman et al. [7] reported a modification of the Gallie technique, known as the Sonntag technique. First, a sublaminar cable is passed under the atlas posterior arch; next, a portion of the iliac crest is placed in between the spinous process of the axis and wedged underneath the atlas posterior arch (Fig. 3). With rigid external fixation, the fusion rate with this technique was reported to be as high as 97%.

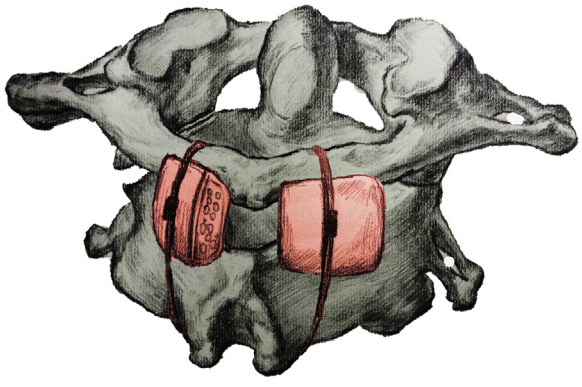

Fig. 2. Brooks-Jenkins technique for atlantoaxial fusion.

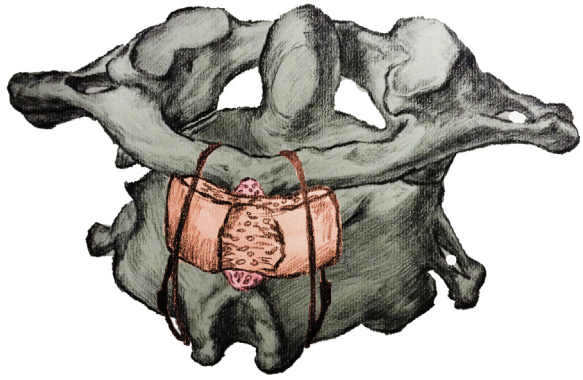

Fig. 3. Sonntag technique for atlantoaxial fusion.

The use of all wiring techniques requires an intact atlas posterior arch and axis lamina; the sublaminar passage of the wire risks spinal cord injury. No wiring technique provides sufficient stabilization, and thus supplemented rigid external fixation, which may reduce patients' quality of life, is required [1,4,7]. Furthermore, new fixation methods provide stronger stability. Therefore, wiring techniques are rarely used alone for atlantoaxial fixation currently.

Interlaminar clamps techniques

The first use of interlaminar clamps in atlantoaxial fixation was reported in 1984, and was called the Halifax technique [8]. After that, the Apofix clamps technique was developed. Many studies reported the application of

Fig. 4. Apofix clamps for atlantoaxial stabilization. The red arrow shows nonunion of graft bone.