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Application of a newly designed mandibular distraction device for navigation surgery in goats

Ming Cai, Yang Chen*, Xiaofeng Lu, Lei Xu, Xudong Wang, Guofang Shen

Department of Oral & Craniomaxillofacial Surgery, Shanghai Ninth People's Hospital, Shanghai Jiaotong University, School of Medicine, Shanghai, 200011, China

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ABSTRACT

Purpose: This animal study is to investigate the accuracy of navigation-guided mandibular distraction osteogenesis with a special designed distraction device by TBNavis-CMFS navigation system.
Materials and methods: Four goats were included in this study. The 3D simulation unilateral mandibular distraction osteogenesis was simulated for 14 mm lengthening in TBNavis-CMFS navigation system. A new designed mandibular distraction device with the detachable adapter for navigation surgery in combination with the specific mandibular dynamic reference frame was applied. Navigation guided distraction osteogenesis was performed on goats and mandible was gradually distracted according to the simulation. Postsurgical 3-D skeletal measurements of presurgical simulations and postsurgical outcomes were compared statistically.
Results: Navigation assisted distraction osteogenesis was successfully performed and the new designed distraction devices worked uneventful. The accuracy of intra-operative registration was within 1 mm. The mandible was lengthened for 14.25 mm in average (13.87–14.36 mm). There were no significant differences between simulation distraction and post-operative 3-D measurements ($p > 0.05$).
Conclusions: A new designed distraction device could be used in navigation guided mandibular distraction osteogenesis on goats with high accuracy by using the TBNavis-CMFS navigation system.

1. Introduction

Intraoral device for distraction osteogenesis (DO) in mandibular deformities have numerous advantages, the clinical success depends on the precise positioning of these devices. Although computer assisted three-dimensional presurgical simulation and planning of mandibular distraction osteogenesis has been widely used, how to transfer these surgical plan to real-time operation with high precision is more concern to surgeons (d'Hauthuille et al., 2005; Bastidas and Bartlett, 2012).

Although most centers nowadays have been using surgical template techniques for precise positioning, navigation-guided surgery has been described as a promising technique. Besides jaw bone DO, most commercially available computer navigation systems for cranio-maxillofacial surgery are designed for foreign body removal, temporomandibular joint arthroplasty and facial skeleton trimming (He et al., 2016; Stein, 2015; Kamizono et al., 2015). There are some limitations for navigation-assisted mandibular DO using regular maxillofacial navigation methods (Dai et al., 2016).

The aim of the study was to evaluate the feasibility and to examine the accuracy of a specially designed distraction device for navigation-guided mandibular DO in goats.

2. Materials and methods

This study was approved by the laboratory of animal study, the local institutional review board and the ethics committee of Shanghai Ninth People's Hospital, Shanghai Jiaotong University School of Medicine (2015–26).

2.1. Design of distraction device

The conception of this new distraction device was to be visualized on screen under a navigation environment during operation. A regular mandibular distraction device (25 mm, Zhejiang Cibei Medical Instrument Co. Ltd.) was used for lengthening the bone. A specially

* Corresponding author. Department of Oral & Craniomaxillofacial surgery, 639 Zhizaoju Road, Shanghai, 200011, China.
E-mail address: drchenyang@yeah.net (Y. Chen).

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designed navigation adapter containing 3 reflective balls was fixed to the distractor by a removable connecting unit (Figs. 1 and 2).

During the surgical procedure, the distraction device could be detected on the navigation software while it was connected to the adapter. The adapter was easily removed by unscrewing the connecting unit after the distraction device reaching the planned position.

2.2. Surgical simulation

Four adult goats were included in the study. Five regular titanium screws were placed in anterior mandibular alveolus as navigational markers. Pre-operative computed tomography was performed on each animal (0.625 mm thickness, light speed 16; GE, Gloucestershire, UK). The digital imaging and communications in medicine (DICOM) data were converted into stereolithography (STL) format, and the unilateral mandibular angle linear DO was designed with a regular distractor in TBNavis-CMFS 2.0 navigation system (Multifunctional Surgical Navigation System, Shanghai, China). The mandible was virtually lengthened for 14 mm and the osteotomy line was perpendicular to the distraction axis. The specially designed mandibular distractor was mapped into the navigation software to replace the simulated distraction device by overlapping the distractor axis (Fig. 3).

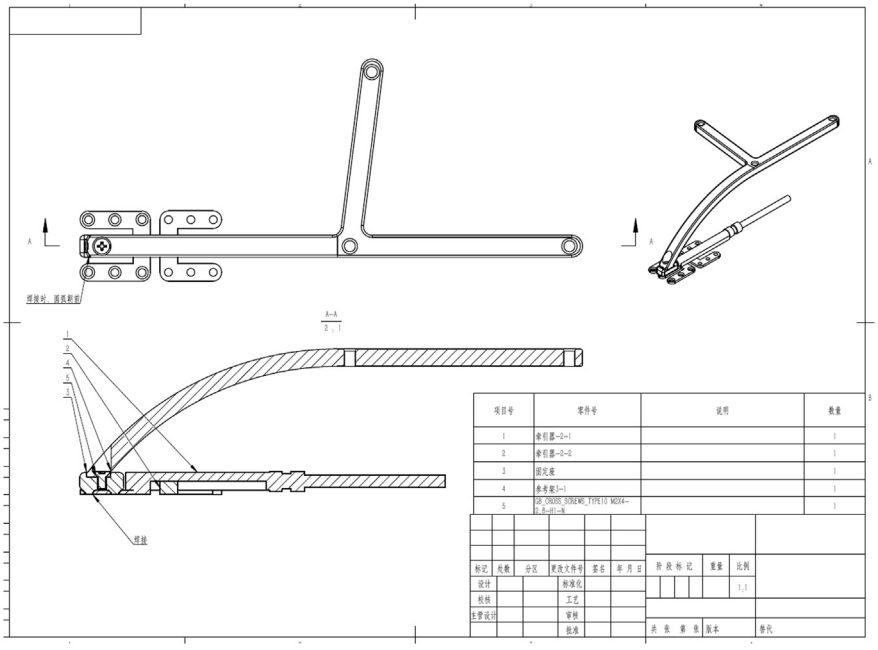

Fig. 1. Blueprint of newly designed mandibular distraction device for navigation-guided surgery.

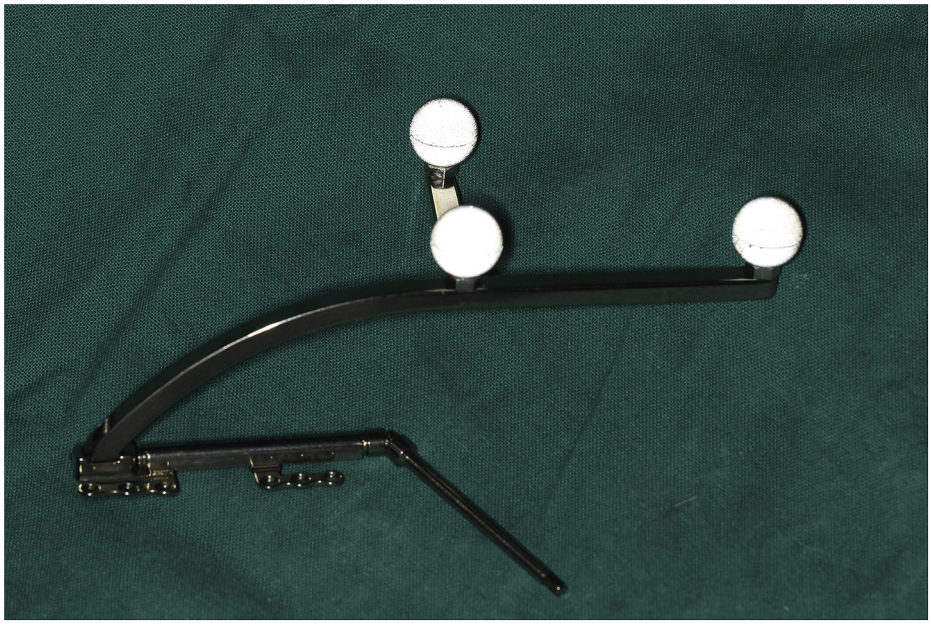

Fig. 2. Prototype of newly designed distraction device.