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Review Article

Application of computer-assisted navigation systems in oral and maxillofacial surgery

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Summary The oral and maxillofacial region has a complicated anatomy with critical contiguous organs, including the brain, eyes, vital teeth, and complex networks of nerves and blood vessels. Therefore, advances in basic scientific research within the field of intraoperative oral and maxillofacial surgery have enabled the introduction of the features of these techniques into routine clinical practice to ensure safe and reliable surgery. A navigation system provides a useful guide for safer and more accurate complex in oral and maxillofacial surgery. The effectiveness of a navigation system for oral and maxillofacial surgery has been indicated by clinical applications in maxillofacial trauma surgery including complex midfacial fractures and orbital trauma reconstruction, foreign body removal, complex dentoalveolar surgery, skull base surgery including surgery of the temporomandibular joint (TMJ), and orthognathic surgery. However, some fundamental issues remain involving the mobility of the mandible and difficulty in updating images intraoperatively. This report presents an overview and feasible applications of available navigation systems with a focus on the clinical feasibility of the application of navigation systems in the field of oral and maxillofacial surgery and solutions to current problems.

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Contents

1. Introduction

The oral and maxillofacial region has a complicated anatomy with critical contiguous organs, including the brain, eyes, vital teeth, and complex networks of nerves and blood vessels. In many cases, it is necessary to perform imaging diagnosis with computed tomography (CT) and/or magnetic resonance imaging (MRI) prior to oral and maxillofacial surgery to clarify the surgical site and surrounding anatomical structures. The rapid development of imaging technology has made it possible to quickly process and visualize the large amount of data produced by various digital imaging modalities. Prerequisites for three-dimensional (3D) visualization and programs for computer-assisted 3D planning of surgical procedures have been established. These information sources are available in the operating room to assist the surgeon at the time of surgery.

Computer-assisted surgery uses image processing data and can be divided into two main categories: computer-assisted pre-surgical planning and navigation. Computer-assisted pre-surgical planning includes preoperative surgical simulation with 3D images or models. Preoperative surgical simulations with 3D images have been used to determine the appropriate positions and sizes of dental implants and to assess the degree of movement during orthognathic surgery. Preoperative surgical simulations with 3D models, such as stereolithographic models, are useful to evaluate treatment plans and to acquire precise representations of the underlying skeletal anatomy of the patient [1]. A system for navigation was developed as a next step forward in the sequence of ''diagnosis-surgical planning-surgery,'' allowing the surgeon to visualize the actual position of surgical instruments in real time on the monitor displaying the CT or MRI 3D data of the patient. Navigation systems involve the integration of imaging with the surgical field, which allows simultaneous visualization of different types of images to reveal structures that are normally visible only intraoperatively and permits navigation in areas of anatomical sensitivity. These systems have recently evolved to improve precision and simplify the surgical procedure by minimizing intraoperative invasiveness. The development of navigation assisted surgery has improved execution and predictability, allowing for greater precision during oral and maxillofacial surgery [2].

This review report presents an overview of available navigation systems and applications with a focus on clinical usefulness and solutions to current problems with navigation systems for use in the field of oral and maxillofacial surgery.

2. Surgical navigation

Surgical navigation is comparable to a global positioning system (GPS) commonly used in automobiles and is composed of three primary components: a localizer, which is analogous to a satellite in space; an instrument or surgical probe, which represents the track waves emitted by the GPS unit in the vehicle; and a CT scan data set, which is analogous to a road map (Figs. 1 and 2). Navigation systems were initially developed for use in neurosurgery and are now commonly used in craniomaxillofacial surgery because of the reliability and an accuracy of less than 1–2 mm [3–7].

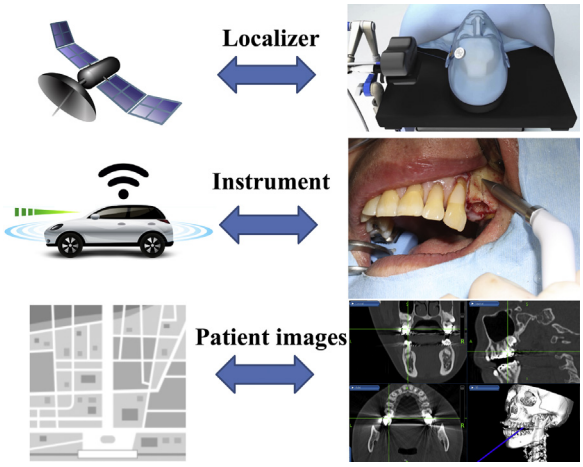

Figure 1 Components of a surgical navigation system. Navigation system is comparable to a global positioning system (GPS) commonly used in automobiles and is composed of three primary components: a localizer, which is analogous to a satellite in space; an instrument or surgical probe, which represents the track waves emitted by the GPS unit in the vehicle; and a CT scan data set, which is analogous to a road map.

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