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Increasing Need for Intraoperative Navigation during Maxillofacial Surgeries in India

Preeti Yadav

PDM Dental College and Research Institute
preeti1999y[at]gmail.com

Abstract: ***In the field of Maxillofacial Surgery precise knowledge of anatomical landmarks is a basic necessity, but other modalities are also needed to provide a basic guide for surgeons in the operative field. Advances in imaging have enabled 3-D visualization of patients' anatomy and surgical field. Nowadays advancements in computer technology allow the real-time tracking of the operative field hence improving the treatment outcome. Navigation Assisted Surgery is an example of advanced diagnostic aid that is nowadays acting as a great adjunct to conventional diagnostic imaging, which accurately locates critical anatomical structures and helps surgeons to find the best and safest way to reach the target and carry out reliable surgeries. Introducing Intraoperative Navigation Devices in India will be a revolutionary step, not just for Maxillofacial surgeries or the Indian Health Care System but also in the overall development of the country.***

Keywords: Intraoperative Navigation Devices, Indian Health care System, Maxillofacial surgeries

1. Introduction

A portable, intraoperative, multi-slice, full-body 32 slices; CT scanner allows Neurosurgeons to perform accurate, precise, and real-time image-guided surgical procedures.

Its features are: It allows imaging to be performed in the operating room, thereby reducing the need to transport patients from the radiology department and enabling the surgeons to make critical decisions during surgery, therefore surgeons are able to assess the patient's condition before they are taken off the operation table.

These devices are gaining fame globally over the past few years rapidly, but due to the lack of training and equipment in India there are very few hospitals using these devices during surgeries, and that too is only for spine and brain surgeries and not for maxillofacial surgeries.

In relation to Maxillofacial Surgery Department, most of the surgeries are so precision-based and moreover in every patient anatomical landmarks are not the same which might lead to drastic failure in surgeries.

Nowadays Diagnostic Imaging plays a vital role in treatment planning and improving the prognosis.

Navigation Assisted Surgery is an example of advanced diagnostic aid that is nowadays acting as a great adjunct to conventional diagnostic imaging, which accurately locates critical anatomical structures and helps surgeons to find the best and safest way to reach the target and carry out reliable surgeries.

Neurosurgery was the first branch to use Intraoperative Navigation Devices during surgery. In 2002 a German Maxillofacial surgeon Dr. Alexander Schramm proposed the idea of using Intraoperative CT from the neurosurgery department to treat Zygomatico-orbital fracture. He stated that in case of zygomatico-orbital fracture if there is only orbit floor involved, then we just need zygoma reduction and through intraoperative navigation, we can assess the condition of the orbital floor after zygoma reduction hence preventing unnecessary intervention, moreover, due to lack of visibility in transconjunctival approach, Intraoperative Navigation devices act as a great diagnostic adjunct during surgeries.[1]

Principle of Image-Guided Surgery:

Basically, it is based on the same principle as that of GPS (Global Positioning System) as both of them synchronizes the location and time data from Point A to B.[2]

The navigation system is made up of 3 main components:

A Localizer- It is similar to a satellite in space. It is fixed on the Patient's head and emits signals.

CT Scan Data- It is similar to a ground control or a road map.

A Surgical Probe- It is similar to the user equipment in a GPS device. It picks up the signal from Localizer and converts it into a digital image. Then a monitor picks up this digital image and orients the patient's present position on preregistered MRI and CT.

Types of Intraoperative Navigation Devices:

There are 2 main types of navigation systems currently available: Optical and Electromagnetic. Both systems performed the same functions, but the technology used to provide information to the surgeon is very different.[3]

Optical System / Infrared System:

This system uses sensors in combination with light-emitting structures or light reflectors that are fixed to the patient's head and to a hand-held probe. In order to track the instrument's position in the surgical field both the light-emitting structures and instrument must be detected by the system camera.[3,4]

Electromagnetic System:

It uses Electromagnetic fields and reference points on a device that is attached to a wired instrument and patient's head. There is no need for computer devices in this system, but the presence of too much metal within the electromagnetic field can cause inaccuracies in the reading.[3,5]

Registration Techniques:

There are two main types of registration techniques:

Marker Based and Marker Free[6,7]

Marker-Based Registration: This technique requires markers, which are detectable both preoperatively and intraoperatively. Example: Referencing Dental Splint[8], Bone Implanted Screw[9], Skin Adhesive Reference Markers[10].

Marker Free Registration: It is totally dependent on the patient's craniofacial anatomy. One approach is to register defined bony protuberances to the corresponding structures apparent on a CT scan. In Laser surface scanning which is applied in much marker-free registration techniques, random points on the facial skin surface are matched to corresponding points on soft tissues on CT/MRI images.[11]

Hybrid Registeration: It is the most recent technique, which incorporates both methods together in one system.[12] Basically, registration overlays one data on another image data, CT is usually used which allows registration of both hard and soft tissues and by overlaying the MRI image data on it very precise navigation is possible.

Clinical Application in Maxillofacial Surgery:

Intraoperative Navigation plays a vital role in surgical procedures in areas with complex anatomy, as in the maxillofacial region.[13]

Maxillofacial trauma surgery and Orbital Reconstruction:

Orbito-zygomatic complex contributes to midfacial width and is one of the most commonly encountered fractures of the face, and restoring both functions and aesthetics is the most challenging procedure for maxillofacial surgeons.[14]

For orbital surgery detailed knowledge of anatomy is the most fundamental requirement, but even after this detailed knowledge, some surgeries fail due to discrepancies in normal anatomy person to person and changes in the position of anatomical structures due to severe trauma, therefore clinical assessment along with imaging techniques like 3D imaging and CBCT plays a vital role in treatment planning, but these are limited till preoperative and postoperative evaluation, however, the major concern is an intraoperative evaluation which might be needed to modify the treatment plan on the spot.

In orbital fracture cases we can take preoperative 3D images and using CAD/CAM we can construct patient-specific implant or can decide the type and size of the titanium implant,[15], however, the major concern here is an adaptation of implant, as we are not sure about the exact position and adaptability of the implant within the orbit, if we are using the transconjunctival approach. It's similar to walking the dark or mist and an intraoperative navigation device act as a light in that darkness. As intraoperative navigation devices give real-time images, it helps us to seat the implant correctly and also allows manipulation using laser intraoperatively, hence giving better results than conventional techniques.[16,3]

In Removal of Foreign Bodies:

Removal of foreign bodies from the craniofacial region can be very risky due to close proximity to vital structures and access difficulties.[15]

For complication-free removal of the foreign body, it's accurate and precise location identification is necessary, especially in intense trauma cases where the foreign body gets imbedded in deeper structures like in the case of a gunshot wound, it may alter the normal anatomy to some extent, making it difficult to precisely locate the exact position of foreign body, even if surgeon identifies the exact location preoperatively, it is very difficult to quickly and accurately detect the location intraoperatively without damaging nearby vital structures.

However, there are many methods to identify foreign bodies like:

Stereotactic Technique- Using two venipuncture needles.[17]

In this technique, two reference needles are positioned sequentially, until both of them meet radiographically at the foreign body. Then, blunt dissection is conducted with one or other needle until the tip of a foreign body is encountered, but its major drawback is that intraoperative radiographic imaging is often difficult to obtain in an emergency situation because of the time needed for imaging, furthermore, it is difficult to discriminate small changes in position on plain radiographs.[17]

C-arm Digital Fluoroscopy- They are used to obtain radiographic images rapidly in order to overcome the limitation of the stereotactic technique, but they provide 2D images, so it is difficult to locate the foreign body in a 3D plane.[18]

Intraoperative Ultrasound Imaging- ultrasound devices were tried to overcome the limitations of the above two techniques but ultrasounds don't provide the precise location, moreover, due to its size, its use in the small oral cavity is very limited.[18] Navigation Systems could provide an accurate location of foreign body in a 3D space therefore very effective in removing the foreign body. However, it cannot account for the change in soft tissue, therefore, can only be used where minimal soft tissue manipulation is required.

Tumor Resection and Reconstruction Surgeries:

Intraoperative navigation makes radical tumor surgery more reliable by showing determined safety margins, preserving vital structures, and guiding reconstruction to preplanned objectives. Several reports have highlighted the role of these devices in precision resection without harming the uninvolved tissues.[19,20]

Earlier when there was limited availability of technology, the surgeon's primary focus was to provide functional satisfaction to the patient, but with intraoperative navigation, the volume of defect can be calculated precisely and we can preserve unharmed tissues and provide the accurate size of grafts to the patient to improve both function and aesthetic of patient, hence providing more mental satisfaction to the patient.

Orthognathic Surgery:

For planning complex surgical movements, preoperative computer imaging and intraoperative navigation are very useful. Osteotomies can be planned, using recently designed CAD/CAM software, and jaw or other anatomic structures can be virtually repositioned in any plane of space.[21,22]

Dentoalveolar Surgery:

Extractions of supernumerary or malposed teeth that are deeply impacted in bone, can be both complicated and challenging, because if we are unable to precisely locate their position it can prolong the duration of surgery and can increase the incidence of trauma or complications, such as injury to adjacent tooth germ. As a navigation system provides real-time images, we can prevent these complications during surgery.[23]

Limitations of Intraoperative Navigation devices:

To begin with, Intraoperative navigation devices are more useful in fixed areas like in the upper two-third of the face, whereas in mandible which can move in all 3 planes, it is difficult to navigate, however, some authors have suggested using fixed special sensors for mandible which can detect the continuous change in mandibular position intraoperatively.[24,25]

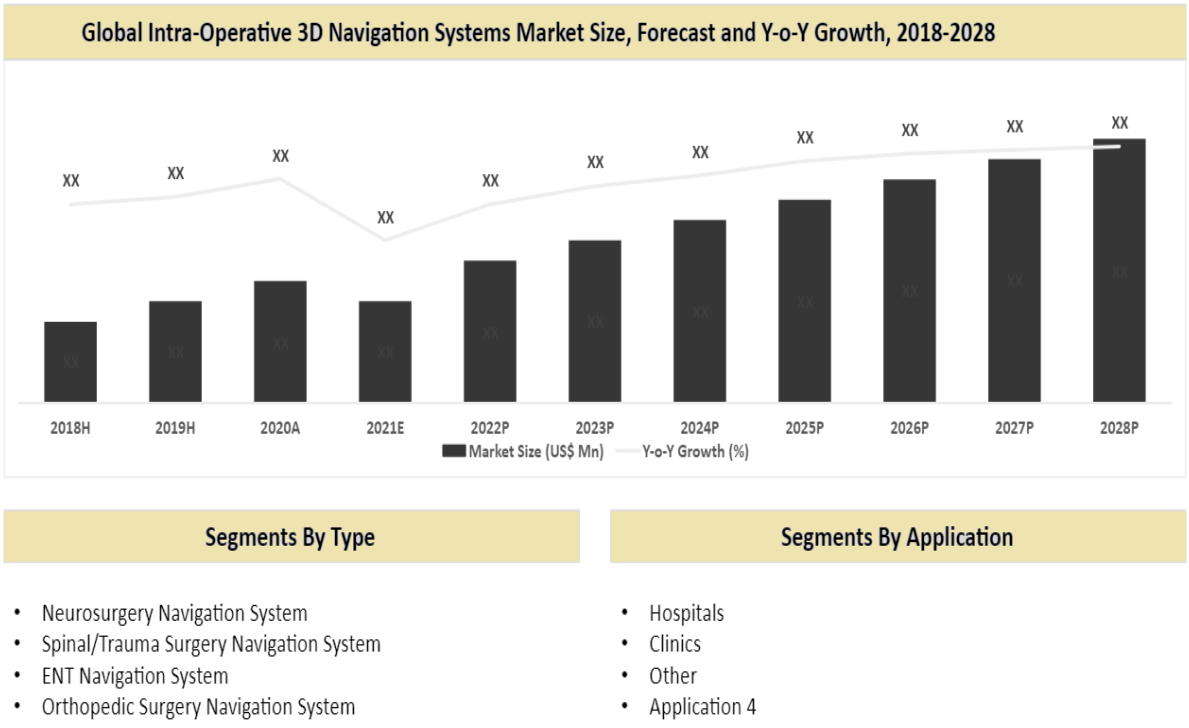
Moreover, in some extensively large tumors where the anatomic position is extremely altered, it is difficult to use these devices. However, both of these limitations are no more considered as in recent studies patients with benign and malignant mandible invading tumors or osteoradionecrosis who were planned for hemi-mandibulectomy were treated successfully using an Electromagnetic Tracking System, although there were significant electromagnetic interferences due to the presence of metallic instruments, it was still acceptable in compared to optical navigation devices.[26]

Furthermore, it is very costly and needs high maintenance costs also, especially for a developing country like India.

In addition, as there is very little exposure to such devices, most of the surgeons prefer the conventional method.

Current Market Analysis Report:

In the current scenario, the market of intraoperative navigation devices is developing at a very fast rate, there is a huge difference in historical and present market size for these devices.

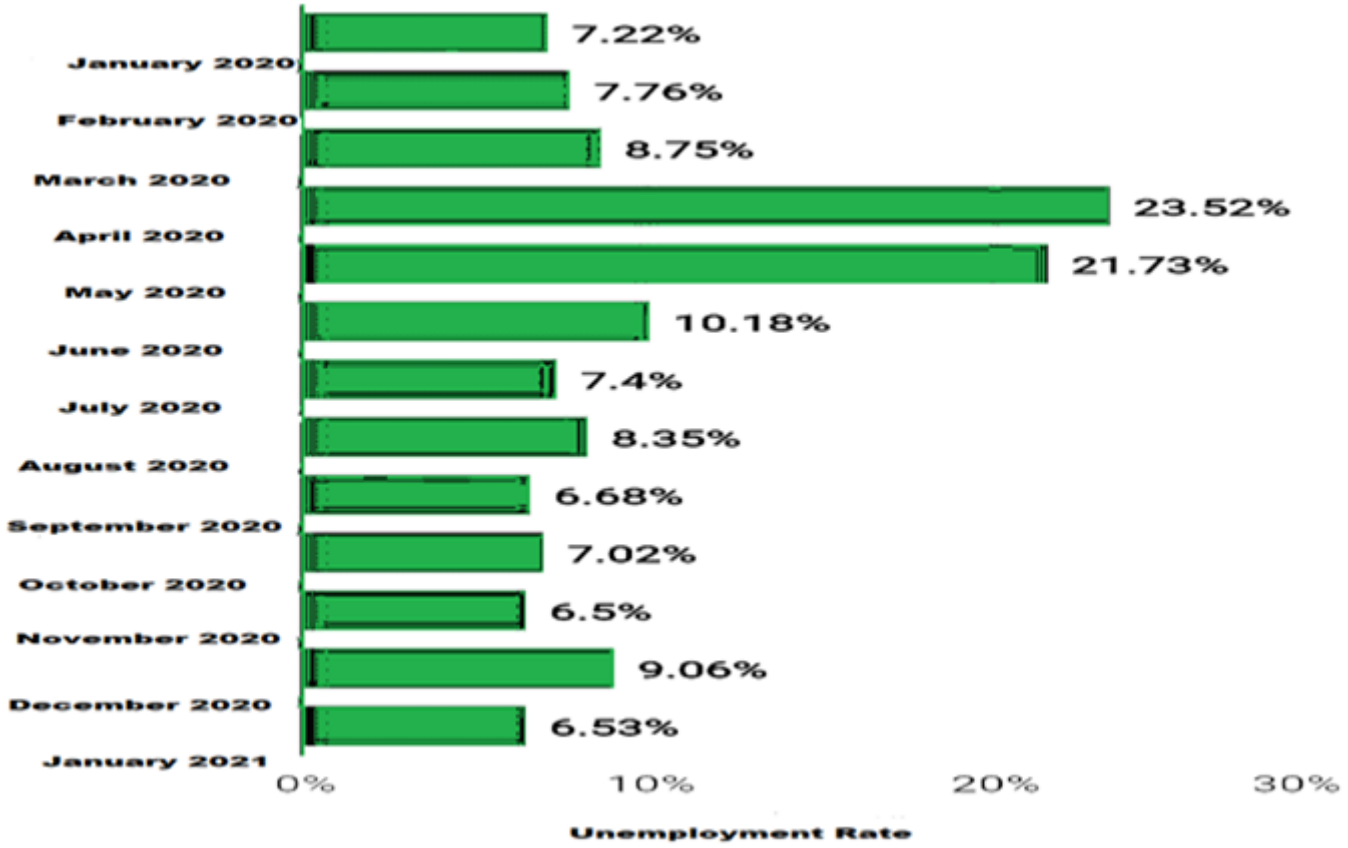


Future of India's Healthcare System with Intraoperative Navigation Devices:

Although these devices are very costly, recently India has become technologically very advanced in just the past few years.

According to the Indian Science and Research and Development industry report May 2021, India is at 48th rank in Global Innovation Index 2020. India's gross expenditure in research and development was forecast to reach US $96.50 billion in 2020 and by 2022, research and development expenditure is targeted to reach at least 2% of the country's GDP.

IT spending in India is estimated to reach US $93billion in 2021 and further increase to $98.5 billion in 2022. Also, the government's new initiative "Make in India" campaign is making it feasible to develop Intraoperative Navigation Devices in India itself, hence making them more cost-effective. Along with it, it would not just be a revolutionary step for future oral surgeries in India, but it would also open up new job opportunities especially in IT firms, and will contribute to India's development, not just in the healthcare field but in overall development and advancement by bringing self-sufficiency and develop India as a global manufacturing hub. Moreover, if these devices are manufactured in our own country it will help provide more training opportunities to surgeons in this field.



As we all know due to present scenario of COVID-19 has impacted India's economy very badly. The number of unemployed citizens has drastically increased, hence introducing these devices' manufacturing in India itself will help provide more and more job opportunities and decrease the unemployment rate to some extent.

2. Conclusion

Intraoperative Navigation Devices are very helpful devices especially in the field of maxillofacial surgery, they help in precise, and minimally invasive surgeries with very good outcomes in both aesthetic and functional aspects. Although it also has some shortcomings, which we can overcome in the near future. Once we start using these Intraoperative Navigation Devices in our surgeries, we will be able to reduce operating time and mishaps to a very large extent.

I strongly believe that these devices are boon for India's oral surgeons and will revolutionize India's whole health care system.

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Author Profile

Preeti Yadav is a BDS Intern in PDM Dental College and Research Institute, Haryana, India. She worked as an Observer at Rajiv Gandhi Cancer Institute and Research Center. She just completed her internship and training program in Cancer biology conducted by Edufabrica, AIIMS Delhi. She conducted a social awareness campaign regarding oral hygiene and cancer in Villages, schools, industrial areas, cities, Arya Samaj Mandir, ITBP camp of district Rewari Haryana, India in November 2021. She has also participated in many National and International conferences and also presented posters and papers at national conferences. She was also a Semi-Finalist in ClinicalKey student National challenge 2020, organized by Elsevier. Her area of interest is Head and Neck Oncology. She has been actively participating in various social works and is looking forward to contributing more to society in the future.