NAVIGATION IN ORTHOPEDIC PRACTICE

Essay
Submitted for fulfillment of Master Degree in
Orthopedic Surgery

By
Reda Gomah Mohamed
M.B.B.Ch

Supervised by

Prof. Dr. Ahmed Amin Galal
Professor of Orthopedic surgery
Faculty of Medicine, Cairo University

Dr. Mostafa Mahmoud
Lecturer of Orthopedic surgery
Faculty of Medicine, Cairo University

Faculty of Medicine
Cairo University
2008

Abstract

Orthopedic surgeons can be proud to lead the way in the development of these tools and the use of these tools to improve their clinical and technical skills for the benefit of patients. The challenge that remains for the clinicians and developers of systems is to understand what these technologies and tools potentially can accomplish and understanding their limitations, and to choose the proper clinical applications which will allow for improved patient outcomes in a cost effective manner. In the near future, these enabling technologies will influence the way surgeons plan, simulate, and execute surgical practice. Currently the only limitation is in the understanding and the imagination of what can be accomplished in the future.

Key words

NAVIGATION IN ORTHOPEDIC PRACTICE

CONTENTS

Page

List of Tables

Table No.	Title	Page

List of Abbreviations

2 D	Two Dimensions.
3 D	Three Dimensions.
C.T	Computed tomography
CAD	Computer assisted design.
CAM	Computer assisted Manufacture.
CAOS	Computer assisted orthopedic surgery.
CATHA	Computer assisted total hip arthroplasty.
CATKA	Computer assisted total knee arthroplasty.
DRB	Dynamic references base .
HTO	High tibial osteotomy .
IREDs	Infrared light -emitting diodes.
JAT K R	Jigassisted total knee replacement.
JBKA	Jig- based knee arthroplasty .
LEDs	Light emitting diodes .
O.R	Operating Room .
OP ALi	Optimizing Alignment.
OR I F	Open reduction and internal fixation.
ROM	Range of Motion .
UKA	Unicompartmental knee arthroplasty.
VSS	Virtual surgery system.

List of Figures

List of Figures *(Cont...)*

List of Figures *(Cont...)*

List of Figures *(Cont…)*

List of Figures *(Cont...)*

INTRODUCTION

Advancement in medical technology over the last several decades has occurred at speed manner.

In our specialty of orthopedics, there are numerous examples of rapid improvements in technology that have markedly improved the care of our patients with musculoskeletal disorder. Within the last two decades, computer and computer operated apparatuses have become very important tools to improve medical skills. The incorporation of digital technology into medical devices and procedures has become a subject of high priority in many industrialized countries. Computer assisted orthopedic surgery systems are currently represent new fields in orthopedic surgery and traumatology ***(John J. Callaghan ,et al., 2005).***

New technologies in computer assisted surgery (CAS) now allow the production of three-dimensional (3-D) displays of soft tissue representation and super impose these images on the patient's actual position ***(Frank L and Lutz N. Peter, 2003)***.

With active robotic technology it is furthermore possible to guide instruments to a treatment site and conduct surgical procedures according to a preoperative plan and repeat procedures .two types of CAS systems have been developed to date: passive and active systems. Passive systems generally perform no action and provide the surgeon with additional information prior to and during the surgical procedure ·Passive navigation systems can be subdivided into three general categories, CT- and MRI- based systems, fluoroscopy-based systems that allow real-time imaging during surgery, and non-image-based systems that obtain data from kinematics or anatomical landmarks ***(David A Simon and Stbphane LAvalle, 1998)***.

For active CAS, robotic technology allows for bones to be machined or drilled during procedures according to the surgeon's specifications therefore, the clinical goals of these computer assisted surgical technologies are as follows:

To develop interactive, patient specific preoperative planners and simulators to optimize the performance of surgery and the subsequent biologic response; and to develop more precise and ultimately less invasive smart tools to assist in the actual measurement and performance of a surgical task ***(Picard. F, et al*, 2004).**

Computer-integrated surgery systems combining medical imaging, robotic and sensor technology, and advanced computation will have a profound influence on surgical practice in coming decades. By improving the information available to surgical and by enhancing the surgeon's ability to perform delicate and precise surgical tasks in a minimally invasive manner, these systems can both improve patient outcomes and ultimately reduce costs associated with disease***(Jolesz F, 1997)***.

AIM OF THE WORK

The aim of this essay is to review the literature about the role of navigation, application, accessibility and achievements in orthopedic practice.

NAVIGATION IN ORTHOPEDIC PRACTICE

Background of NAVIGATION IN ORTHOPEDIC PRACTICE

Throughout history, physicians have tried to improve visibility of the inside of the human body to understand the complexity of normal and diseased body structures. Dissection of the human body began several thousand years ago. The next milestone in improving visibility did not occur until the 19^{th} century, when Roentgen discovered the x-ray and introduced plane radiography ***(Frank L and Lutz N Peter, 2003)***.

Surgeons in different specialties, especially orthopedics, have succeeded in transferring the powerful images of radiography to operating rooms via X-ray fluoroscopy. The advent of the computer and subsequently computed tomography (CT) in late 20^{Th} century opened a new horizon of better accuracy and visibility. Surgeons tried to transfer the operating room to the CT scan suite and vice versa to enable image-guided surgery in real time, but their attempts were not successful. the introduction of position-tracking devices made the application of image-guided surgery possible by linking the different steps of imaging, planning, and surgical implantation, even when performed at different times. ***(John J Callaghan et al., 2005)***.

Modern computer-assisted technology in the form of robotics and navigation started in the 1980s with several neurosurgical applications. The technology was sub-sequently transferred from neurosurgery to orthopedics in the area of spine and then gradually to hip and knee surgery. Practical application of CAS in orthopedics stared in the early 1990s when robotic techniques were used for femoral canal preparation in total hip arthroplasty. The technical development gradually moved from active robotics toward passive navigation systems. The earliest navigation system were image based and used CT scans followed by systems that allowed navigation by intraoperative fluoroscopy or without any previous imaging (image-free) ***(Musahl V et al., 2002)***.

Definition of computer-assisted surgery (navigation):

It is the application of computer-enabled technology at any stage (*preoperative, intra-operative,* and *postoperative*) in the surgical management of orthopedic conditions with the use of various systems *(active, semi-active, passive)* performed for several applications (*planning, simulation, guidance, robotic and/or training*) ***(Anthony .M .DiGio, 1998)***.

Classification and characteristics of computer-assisted orthopedic surgery systems

A simple and clinically based classification system for CAOS was presented by Picard et al. They classified CAOS into *1) active, 2) semi-active*, or *3) passive systems* and by the imaging requirements*, 1) image-free* and *2) preoperative* or *3) intraoperative image-based*, thus creating a 3*x*3 classification matrix ***(Picard F et al., 2004)***.

Robotics