

Workspace Based Design Proposal for Surgical Robot with Endoscopic Endonasal Transsphenoidal Approach

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Abstract

The robot in neurosurgical application is still unfamiliar for neurosurgeons because in the neurosurgical operation, neurosurgeons' stereoscopic view and depth perception could be designed and achieved by themselves. However, the great role of robots including high precision, repeatability and endurance help formulate neurosurgeon's assistants particularly in minimally invasive surgery. Endoscopic endonasal transsphenoidal approach is very challenge procedure not only for neurosurgeons but also for robotic neurosurgery. To create the robotic system with endoscopic endonasal transsphenoidal approach is the main objective of this study under workspace based design.

Keyword: endoscopic endonasal transsphenoidal approach, robotic neurosurgery, workspace based design, minimally invasive surgery

I. INTRODUCTION

Pituitary tumors are the tumors sitting in the sellar region and account for 10% of all diagnosed primary brain tumors (1,2). There are two classifications of this tumor including microadenoma (pituitary tumor diameter <1CM) and macroadenoma (pituitary tumor diameter >1CM). Invasive pituitary tumor is defined as this tumor aggressively invading to nearby structure such as cavernous sinus, optic nerve and vital neurological structures. To manage this tumor, surgery is required. Traditional transcranial and/or transfacial surgical approaches are indicated when the tumor is large and occupied suprasellar area. In contrast, the transsphenoidal approach is costumed directly via sphenoid sinus and

indicated for the tumor that sitting in the sellar region. According to this approach, there are two entry routes among sublabial and endonasal approach. With rigid, straight endoscope through the constrained nostril entry, the endonasal approach is acceptable and challenging application in the minimally invasive surgical means. However, to enhance dexterity, accuracy and precision of this manipulation to access the very small and susceptible region, the surgical robot plays a great challenging role. In this article, to examine and propose the surgical robot conceptual design for endoscopic endonasal transsphenoidal approach is accessible. This particularly challenging application with the surgical robot should comprise of two main demanding concepts. The first concept is the navigation system which will be based on the virtual fixture system. The second concept is the workspace based design for the robot for endoscopic endonasal transsphenoidal approach.

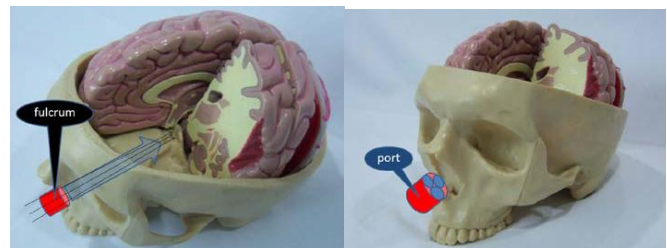


Fig 1: this illustrate presents the overall idea of trajectory of the robot manipulator

II. LITERATURE REVIEWS

Regarding the search engine, the search mean was narrowed and included all result, journal contents and by

means of a combination of text words, “transspheoidal robot”. Pubmed and IEEE database were conducted covered volumes published last 10 years. As a result, there were three topics relevant found in Pubmed. No result was found from IEEE.

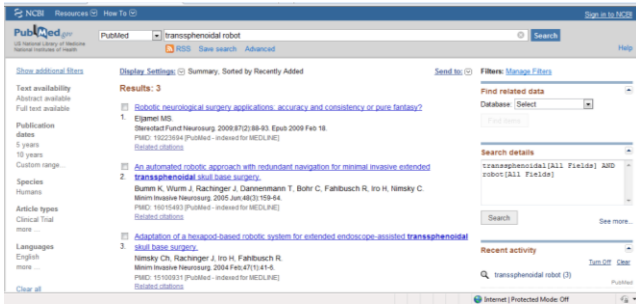


Fig 2: Pubmed result

All these three studies revealed the feasibility of the robot to perform transspheoidal approach. However, the bulkiness of the robot and their conceptual designs were totally different. Eljamel MS presented the accurate and consistent of the robotic system in 8 performances of transspheoidal approach (5). The PathFinder (Prosurgics, UK); a neurosurgical robotic system with 6 degrees of freedom, was used in his study. Bumm K et al revealed both teleoperation system and fully automated modes of sphenoidectomy in cadaver (6). The system for robot-guided surgery in combination with redundant navigational control was developed and determined under CT imaging. Unlike Nimsky Ch et al, a hexapod-based robotic system for extended endoscope-assisted transspheoidal approach was showed and the new possibility was determined (7).

III. METHODOLOGY

The concept of the navigation system; based on the virtual fixture system, is defined as the invisible wall. This wall will prevent the nearby neurological structure damage which could be happen during the operation. Neurosurgeon could be able to plan the virtual fixture preoperatively. With the opened software; 3d slicer version 4.1.1, the path planning, trajectory and the definite target could be selected under MRI brain of the patient. This could be linked and precalculated by MATLAB. The diagram is shown in the Fig 3.

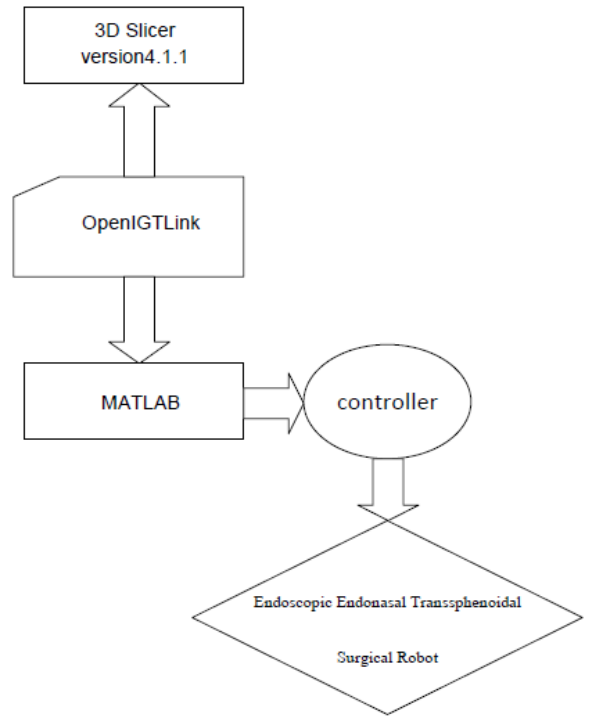


Fig 3 : OpenIGTLink; as module linker, will supply an algorithm for communications between computers and the robot under several varieties of image-guided applications

Endonasal transspheoidal approach and the surgical workspace are defined and shown in the Fig 3. The cone-like shape workspace is costumed to fit the small sellar area. The robotic arm is shaped as antenna-like with flexible tip which could be control as teleoperation mode as shown in Fig 4.

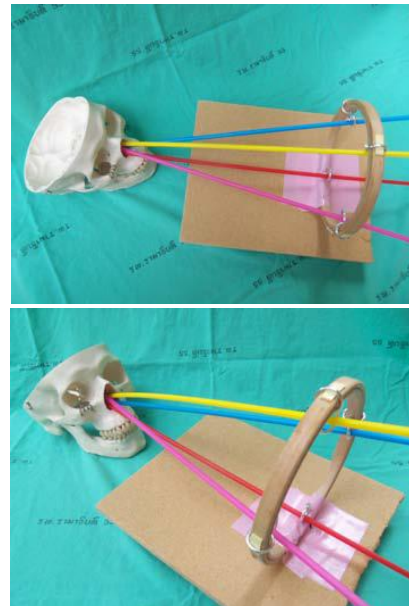


Fig 4: this illustrate presents the design of workspace for endonasal transspheoidal approach

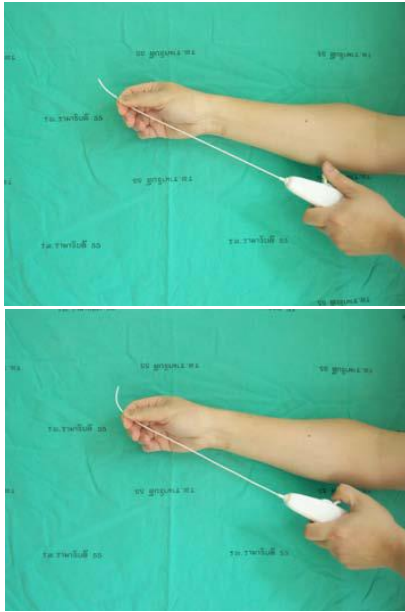


Fig 5: this illustrate presents the design of antenna-like with flexible tip for endonasal transsphenoidal approach surgical robot

IV. DISCUSSION AND CONCLUSION

Because of the small and limited sellar area, the antenna-like with flexible-tip arm is design to manipulate and dissect the friable and soft pituitary tumor feasible and safe. The teleoperation will allow the surgeon to operate under endoscopic view. The endoscope is held in place during the operation and could be translated and rotated as the neurosurgeon desired. The robot is designed to manipulate in 6 DOF.

This conceptual scheme of endoscopic endonasal transsphenoidal approach surgical robot will be simulated and fabricated to finalize the robot prototype and set up the experiment in cadaveric study later.

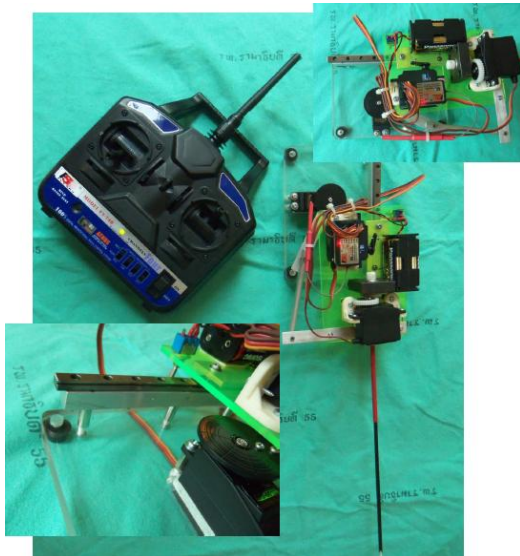


Fig 6: this illustrate presents the prototype of antenna-like with flexible tip for endonasal transsphenoidal approach surgical robot

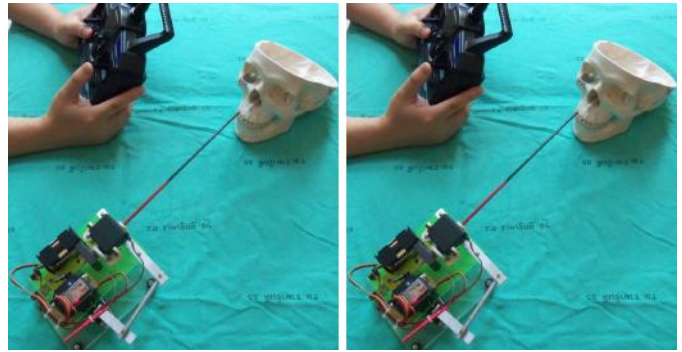


Fig 7: this illustrate presents the antenna-like with flexible tip for endonasal transsphenoidal approach surgical robot under teleoperation

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