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Cone-beam Computed Tomography Guidance in Functional Endoscopic Sinus Surgery: A Retrospective Cohort Study

Hesam Jahandideh[1], Azam Yarahmadi[2], Shahin Rajaieh[3], Amin Ostvar Shirazi[1], Maryam Milanifard[4] and Amir Yarahmadi[1*]

[1]Department of Otolaryngology - Head and Neck Surgery, Firoozgar Hospital, Iran University of Medical Sciences, Tehran, Iran.
[2]Department of Radiology, School of Dentistry, Islamic Azad University, Tehran, Iran.
[3]ENT and Head and Neck Research Center, The Five Senses Institute, Iran University of Medical Sciences, Tehran, Iran.
[4]Department of Anatomy, School of Medicine and Pain Research Center, Hazrat Rasool Hospital, University of Medical Sciences, Tehran, Iran.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Introduction: Using image-guided intra-operative navigation systems in surgeries like functional endoscopic sinus surgery (FESS) has become widely accepted as an effective tool for improvement of surgical outcomes and reduction of complication. Cone-beam CT (CBCT) is a variant of computed tomography imaging that has developed as a cross-sectional and potentially low-dose technique to visualize bony structures in the head and neck. In current study, it was tried to evaluate surgeons' satisfaction with CBCT intra-operative navigation imaging as well as image quality prior to FESS and post-operative complications.
Methods: In this prospective study, the included patients who were candidates for FESS underwent CBCT from January to June 2019. The data regarding demographic information, CBCT

**Corresponding author: E-mail: amiryarahmadi8693@gmail.com;*

findings and diagnosis were extracted. The surgeons' satisfaction with intra-operative navigation imaging and image quality was quantified using Visual Analogue Scale (VAS) (ranging 0 – 10). Furthermore, patients were contacted 3 months later to ask for their satisfaction with the operation using VAS and post-operative complications evaluated.

Results: Totally, 39 patients were included. The mean age was 40.74±5.75 and 20 patients (51.28 percent) were male. Two surgeons performed this operation separately; one of the surgeons performed 20 (51.28 percent) FESS and the other performed 19 (48.71 percent). The mean satisfaction of the surgeons of CBCT guided FFESS was 8.69±0.92. After the 3-month follow up, patients' satisfaction score was 8.21±1.89. No postoperative complications were reported.

Conclusion: Based on the surgeons' point of view, CBCT was shown to be reliable for image-guided FFESS. Furthermore, the outcome and complications of performed surgeries were similar to those performed with computed tomography intra-operative navigation imaging.

Keywords: Cone-beam computed tomography; paranasal sinuses; sinusitis; surgery; endoscopy.

1. INTRODUCTION

Nowadays, functional endoscopic sinus surgery (FESS) is the choice treatment for the skull base diseases and rhinosinusitis [1]. This technique includes insertion of a slender endoscope and other tools through nostrils to widen sinus pathways by removing tissue and bones [2]. The extent of FESS varies according to the surgeons' individual practice and the extent of disease. This manipulation during the surgery is of great importance because the aforementioned bones and cartilages are adjacent to some critical anatomical structures such as optic nerve, carotid and anterior ethmoidal artery [3]. Damage to these structures is the main source of the major complications of FESS such as hemorrhage, blindness, oculomotor deficits and cerebrospinal fluid leak [4-6]. Therefore, one of the fundamentals for successful FESS is knowledge of the complex anatomy of the paranasal sinuses.

Introduction of imaging-guided surgeries (IGS) in this field has drastically decreased rate of complications [7]. Furthermore, IGS has led to surgeries with an increased efficacy including decreased operation duration, decreased workload and improved surgical outcomes [8]. Computed tomography is the method of choice for the evaluation of osteomeatal complex and paranasal sinuses. Despite the high sensitivity and specificity of this method, its high radiation dose, high cost and required infrastructure have made this modality limited to be applied routinely [9]. One of the relatively new modalities developed is Cone-beam Computed Tomography (CBCT). The relatively compact design and low radiation dose of CBCT have made this modality an attractive one for diagnosis, surgical planning and intra-operative application in head and neck surgeries [10,11]. CBCT permits multi-planar visualization of craniofacial structures for the evaluation of various pathologies and problems [12]. Albeit these advantages, CBCT has some limitations compared to routine computed tomography scanning, including absence of a Hounsfield scale, poor density resolution in soft-tissue imaging, and higher noise [13].

In line with the previous advances in image-guided surgery (IGS), to decrease the invasiveness and decrease expenses in surgeries, which is one of the main objectives of health care systems all over the world, the current study was designed to evaluate the efficacy of CBCT guidance in FESS based on the surgeons' experience and outcome of operations.

2. METHODS

In the current single-center prospective study, all patients who were candidates for FESS underwent CBCT in Firoozgar Clinical-Educational Center, which is the referral center for maxillofacial surgeries in Iran, during January to June 2019 were included in the study. This was in concordance with ethical principles of the Helsinki Declaration (1964) and was approved by the Ethics Committee at the Iran University of Medical Sciences.

The inclusion criteria included:

1. Revision sinus surgery
2. Distorted sinus anatomy of development, postoperative or traumatic origin

3. Extensive sinonasal polyposis: pathology involving the frontal, posterior ethmoid, and sphenoid sinuses
4. Disease abutting the skull base, orbit, optic nerve or carotid artery
5. CSF rhinorrhea or conditions where there is a confirmed or suspected skull base defect
6. Benign and malignant sinonasal neoplasms

Finally, 39 patients met the criteria and were included in the study. After obtaining CBCT images, patients with positive pathologic findings on CBCT underwent therapeutic sinus endoscopy under general anesthesia, and those without pathologic findings on CBCT underwent diagnostic sinus endoscopy under regional anesthesia within 1 week after CBCT scanning. The corresponding medical records were extracted from the hospital database. The information about age, gender, physical examinations, diagnosis, CBCT findings, intra- and post-operative complications were extracted from the documents. Also, Visual Analogue Scale (VAS) on a 10-cm line was used to quantify the surgeon's satisfaction with the intra-operative navigation imaging and image quality using CBCT. Moreover, a 3-month follow-up after FESS was performed by acquiring patients' satisfaction based on VAS score via telephone.

Surgical plane, Prisman et al.,2011 descibed and it breifly is explained to form ''CBCT images were resliced in real-time to represent a plane parallel the plane created by the tip of the endoscope, at a distance from the endoscope controlled by the user. This plane represents the radiologic equivalent of the endoscope'' [14].

For description of the groups, descriptive statistical methods were used and data were expressed as mean ± standard deviation or frequency and percentage. Kruskal-Wallis and U-Mann Whitney test were used to compare satisfaction scores in different groups. Statistical Package for the Social Sciences (SPSS) software version 16.0 (SPSS Inc., Chicago, IL). P-value less than 0.05 was considered statistically significant.

3. RESULTS

During 3 months, 39 patients were included. The mean age was 40.74±5.75 and 20 patients (51.28 percent) were male. Final diagnoses included 32 nasal polyposis (82.1 percent), 4 fungal sinusitis (10.6 percent), 1 cerebrospinal fluid leak (2.6 percent), 1 Ameloblastoma (2.6 percent) and 1 Meningioma (2.6 percent). Two surgeons performed this operation separately; one of the surgeons performed 20 (51.28 percent) FESS and the other performed 19 (48.71 percent). The most common indication for CBCT was revision surgery for polyposis (66.6 percent). A sample CBCT image of one of the patients is shown in Fig. 1. None of the patients developed any major intra-operative and post-operative complications.

The mean satisfaction of the surgeons of CBCT guided FESS was 8.69±0.92. The satisfaction scores between the two surgeons were not statistically significant (p=0.58). Furthermore, the satisfaction scores between different genders (p=0.77) and diagnoses (p=0.2) were not statistically significant. After the 3-month follow up, the surgeons' satisfaction score with surgery outcome was 8.21±1.89.

4. DISCUSSION

In the current study, it was found that both surgeons were highly satisfied with the intra-operative navigation imaging accuracy and image quality. Furthermore, implementation of this technique led to no major complications during or after the operation. This CBCT guided FESS was shown capable regardless of the patients' demographic information and the final diagnosis.

FESS is the most regularly performed surgery in Ear Nose and Throat practices for the treatment of medically refractory chronic rhinosinusitis with and without polyposis and dental sinusitis which are often unrecognized and labeled as chronic rhinosinusitis [15]. FESS is also a crucial surgical approach to epistaxis management, antrochoanal polyps, skull-base surgery and sinonasal tumors [16,17]. FESS is usually performed to restore nasal patency without excessive exposure, improved delivery of washes, medications and olfactory stimuli, removing inflammatory foci and maintaining natural mucociliary pathways [18]. Albeit the increasing popularity of FESS, the procedure is fraught with potential morbidity due to intracranial and orbital complications. Complications of FESS are either major or minor including complications include cerebrospinal fluid (CSF) leak or orbital hematoma, intracranial injury, orbital hematoma, blindness, diplopia, extraocular muscle injury, or death [6,19,20]. In order to reduce these complications by increasing surgeons' orientation of the anatomy IGS was proposed [21].

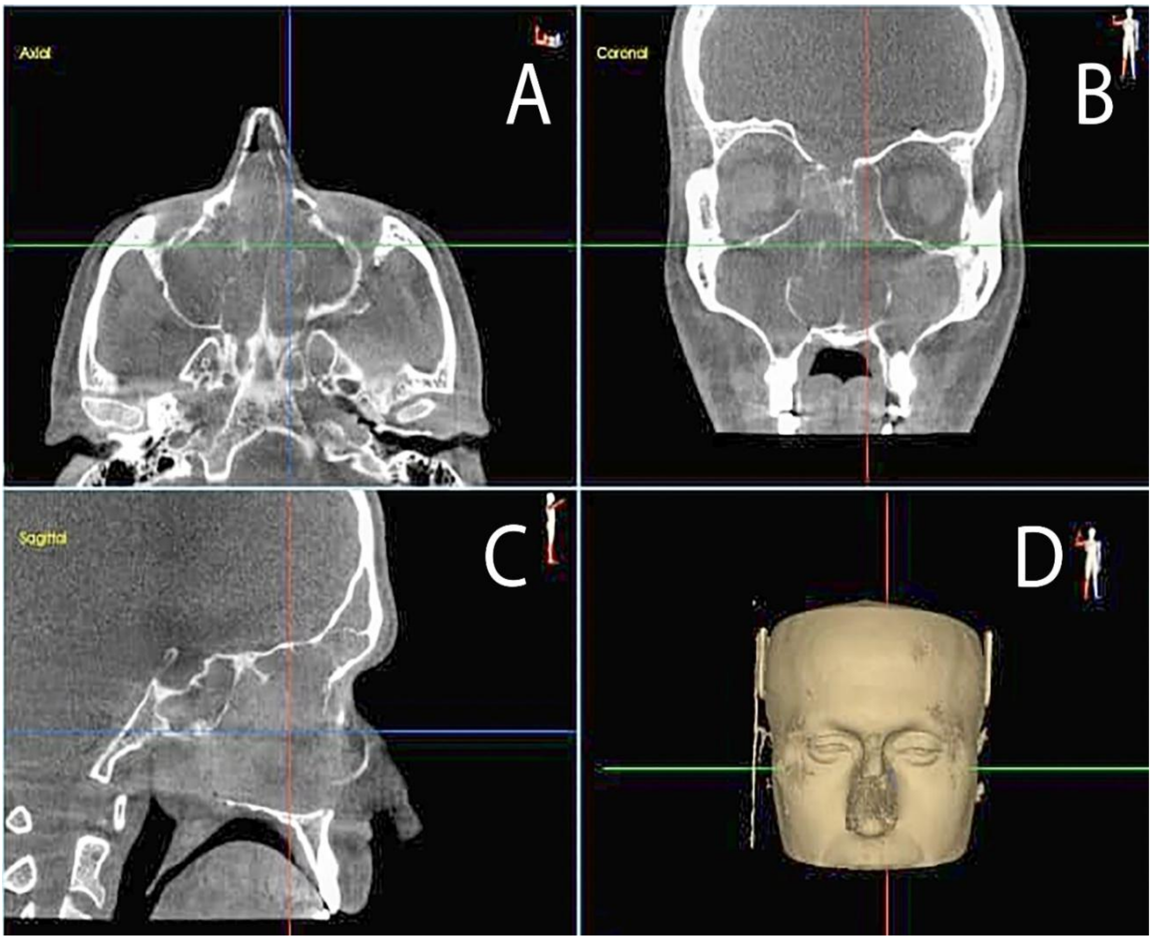

Fig. 1. Axial (A), coronal (B), sagittal (C) and 3D re-construction of the images acquired using CBCT of a patient with polyposis and chronic rhinosinusitis

Recently, CBCT is also proposed as one of the modalities capable of providing guidance during FESS. The relatively low radiation dose, compact design, increased feasibility and high-quality bone definition has made CBCT an appropriate modality for paranasal sinuses, in line with this issue as the inflammatory sinus diseases are often recurrent and leads to repetitive imaging acquisitions, in such patients CBCT provides a good spatial resolution with a reduced field of view [22,23]. It has been already shown that about 75 percent of head and neck surgeons do not know about the utilization of CBCT in their field as inflammatory sinus disease is often recurring and results in repetitive imaging requests, in such cases CBCT provides good spatial resolution with reduced field of view [1]. The effective dose in CBCT ranges from 13 to 500 µSv, which most fall into 30 to 80 µSv and the image quality can vary depending on the radiation dose; images with higher radiation often produce better image qualities. In comparison, standard panoramic radiography delivers ~13 µSv and multidetector CT delivers ~860 µSv [24]. In a study by Alspaugh et al. the spatial resolution of paranasal images using CBCT and multidetector CT were compared and it was concluded that 12 line pairs per centimeter could be achieved with an effective dose of 0.17 mSv in CBCT compared to the 0.87 mSv for 11 line pairs per centimeter spatial resolution in a multi-detector computed tomography (MDCT) [25]. In another study by Rafferty et al. investigating application of C-arm CBCT in endoscopic sinus surgery it was concluded that soft tissue and spatial contrast was sufficient to be used as an assistive intra-operative navigation imaging guide for frontal recess surgery [26]. This was also similar to that found in our study, supporting the use of CBCT guided FESS. Utilization of intra-operative CBCT in study of Batra et al. was found to be succFESSful to visualize stent locations and residual bony partitions, leading to surgical revisions.

Beside all these capabilities, there are still ongoing controversies about the use of CBCT. This technology is limited by the lack of experience in this field and especially relatively inadequate literature. The ACR Practice Guideline for CT of the head and neck recommends that bone and soft tissue algorithms be used for imaging studies [27]. Because of low CBCT radiation dose, only the bony details can be inspected while soft tissue lacks the required details to be examined [28,29]. However, in current study, all required approaches in FESS using aided intra-operative navigation imaging by CBCT were performed precisely with minimal complications, therefore the soft tissue details shown in CBCT images seem to be sufficient to guide the surgeon during FESS.

The main limitation of the current study was a semi-qualitative and subjective assessment of intra-operative navigation imaging and image quality in CBCT. Furthermore, the comparison between CT and CBCT is a multi-aspect issue, so choosing whether CBCT could be used or not depends on the patients' clinical condition and surgeon's intra-operative navigation imaging preferences. The other limitation was the low number of patients with diagnoses other than polyposis, which makes it relatively difficult to investigate and generalize CBCT performance.

5. CONCLUSION

The surgeons performing FESS in the current study have recognized CBCT as a reliable and accurate modality for image-based guidance. Furthermore, the outcome and complication of FESS using CBCT intra-operative navigation imaging were similar to what observed using CT intra-operative navigation imaging. However, the current study lacks the FES Sential perquisites to lead to a change in IGS protocol, this study has provided a limited set of data to support capabilities of CBCT in IGS.

CONSENT

It is not applicable.

ETHICAL APPROVAL

This was in concordance with ethical principles of the Helsinki Declaration (1964) and was approved by the Ethics Committee at the Iran University of Medical Sciences.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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