

Utility of Intraoperative C-Arm Fluoroscopy for Frontal Sinusotomy

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전두동 개방을 위한 술 중 C-Arm의 유용성

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이 승 신

부비동 내시경 수술은 내시경의 특성상 뇌척수액 비루, 뇌수막염, 안외손상, 경동맥손상과 같은 심각한 합병증을 초래할 수 있다. 특히 전두동의 수술이 기술적으로 가장 어렵고 합병증의 발생위험이 높다. 이러한 잠재적 합병증으로부터 안전하게 수술을 시행하기 위해 많은 보조적 방법들이 개발되었는데 image-guided surgery (IGS)이 가장 대표적이다. 많은 술자들이 IGS의 장점으로 안전하고 완전한 수술을 가능하다고 하지만 IGS 또한 특정한 한계가 있다. 저자는 15명의 부비동 내시경 수술 환자에서 전두동 수술을 위한 전두와(frontal recess)로의 접근 시에 C-arm 투시촬영을 이용하여, 모든 환자에서 전두동 수술을 합병증 없이 성공적으로 시행할 수 있었다. 수술 중 C-arm 투시촬영 평균 횟수는 2.8회(2~5회)였다. 수술 후 6개월에 모든 환자의 전두동 개구부는 개방된 상태로 잘 유지되었다. 술 중 C-arm 투시촬영은 IGS와 비교하여 사용이 간단하고 비용이 적고 해부학적 변화를 실시간으로 표시할 수 있는 장점이 있다. 이 결과를 토대로 저자는 전두동 수술 시에 C-arm 투시촬영이 IGS에 상호보완적으로 사용될 수 있는 방법이라고 생각한다.

중심 단어 : 전두동 · C-arm 투시촬영 · 부비동 수술 · Image-guided surgery.

Introduction

Endoscopic sinus surgery (ESS) has become the procedure of choice for the treatment of paranasal sinus diseases. However, ESS presents challenges to surgeons

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due to the learning curve and potential complications, such as, cerebrospinal fluid rhinorrhea, meningitis, orbital injury, and carotid artery injury¹⁾. In particular, frontal sinusotomy appears to be the most difficult and risky procedure during ESS due to anatomical complexity and frequent individual variations of the frontal recess region²⁾. Furthermore, the frontal sinus outflow tract is located at an angle that makes the endoscopic intranasal approach difficult³⁾. In addition, in cases of revision surgery, possible hazards during frontal sinusotomy are substantially increase by anatomic landmark distortions.

In the early 1990s, image-guided surgery (IGS) was introduced to improve intraoperative localization, and many authors have reported that IGS confers benefits in terms of safety and complete sinus surgery⁴⁻⁶. Nevertheless, despite such advances, IGS has its limitations.

Intraoperative C-arm fluoroscopy is mainly used in orthopedic trauma surgery. We utilized this system to determine routes to the frontal recess during ESS in selected patients. This paper describes our experiences of frontal sinusotomy using intraoperative C-arm fluoroscopy and discusses the possible benefits and limitations of this method.

Subjects and Methods

We selected 15 patients who underwent ESS from January 2005 to July 2007. In these patients, we used intraoperative C-arm fluoroscopy (GE OEC 9,800, General Electric, Salt Lake City, UT) for frontal sinusotomy. There were 2 men and 13 women, with ages ranging from 29 to 71 years. The decision whether or not to use intraoperative C-arm fluoroscopy was made intraoperatively for various reasons, such as, revision surgery or the presence of frontal cells. We received informed consent preoperatively from all candidates concerning the possible use of intraoperative C-arm fluoroscopy.

We checked the C-arm intraoperatively by placing a frontal sinus curette or frontal sinus seeker at the point of concern (Fig. 1). By integrating information acquired from C-arm and CT images, and endoscopic views, we were able to complete frontal sinusotomies thoroughly

and safely due to added confidence regarding the frontal recess anatomy. In all patients, lateral view was sufficient (Fig. 2).

Results

Ten of the 15 patients were undergoing revision surgery (Table 1). Agger nasi cells, supraorbital cells, and frontal cells were detected in 10, 7, and 6 of the patients, respectively. In two patients, we could not identify pneumatization patterns around the frontal recess due to anatomic derangement caused by previous surgery. Of the 9 patients in whom we could identify uncinete process attachment types, lamina papyracea, skull base, middle turbinate, and mixed types were detected in 5, 1, 1 and 2



Fig. 1. Intraoperative set-up of the C-arm system. Intraoperatively, the C-arm is checked by placing a frontal sinus curette or frontal sinus seeker at the point of concern. Information acquired in endoscopic view and from C-arm and CT images, increases confidence of the frontal recess anatomy.

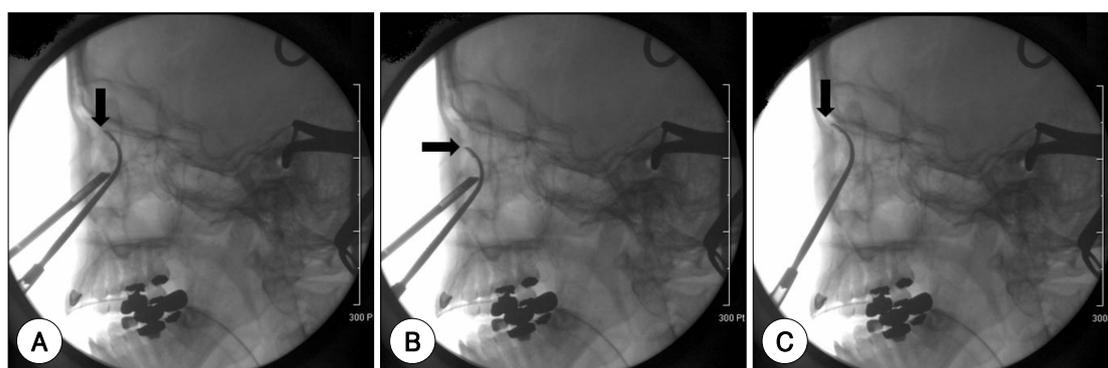


Fig. 2. Visualization of the frontal recess and sinus with a locating frontal sinus curette at the frontal recess (A), anterior wall of the frontal sinus or nasofrontal beak (B), and within the frontal sinus (C).

Table 1. Patients profiles with pneumatization and uncinete process attachment patterns

Patient	Sex/Age	Op	Cells around frontal recess	Uncinate process attachment	Patency after 6mo
1	F/29	P	AN, SO	SB	Yes
2	F/33	P	AN, FC1	LP	Yes
3	M/44	P	AN, FC4, SO	LP	Yes
4	F/45	P	AN	Mixed	Yes
5	F/41	P	AN, SO	MT	Yes
6	F/43	R	SO	n.s.	Yes
7	F/61	R	AN, FC3	n.s.	Yes
8	M/38	R	AN, SO	LP	Yes
9	F/39	R	AN, FC3	n.s.	Yes
10	F/71	R	AN, FC1	Mixed	Yes
11	F/34	R	n.s.	LP	Yes
12	F/43	R	n.s.	n.s.	Yes
13	F/65	R	AN, FC2	n.s.	Yes
14	F/40	R	SO	LP	Yes
15	F/38	R	SO	n.s.	Yes

Op : operation, P : primary surgery, R : revision surgery, AN : agger nasi cell, SO : supraorbital cell, FC : frontal cell, MT : middle turbinate, LP : lamina papyracea, SB : skull base

patients, respectively. Frontal sinusotomy was performed successfully in all patients without complication. The average number of C-arm lateral images taken, including scout images taken to allow the C-arm to be precisely positioned, was 2.8 (range of 2 to 5). The frontal sinus outflow tract remained patent at 6 months after surgery in all patients.

Discussion

In all patients, C-arm lateral view only was sufficient for frontal sinusotomy. The frontal recess is bordered by the middle turbinate medially and by the lamina papyracea laterally, both of which are easily detected by operators during the procedure. Therefore, for precise localization of the frontal recess in the operative field, additional anatomic information in the anteroposterior dimension acquired in C-arm lateral view is of considerable help.

IGS enables the surgeon to navigate the complex anatomy of the sinus region. However, IGS has some limitations. In particular, it cannot reflect anatomic changes during a procedure, because it presents surgeons with positional information based on image data obtained preoperatively. Furthermore, it may have a registration error range of 2mm^{7,8)}. In addition, anatomic drift may

occur during a procedure, usually due to headset movement, and IGS requires more operative time and is more expensive⁹⁾. Moreover, because preoperative registration is a requisite, surgeons cannot decide to use IGS intraoperatively.

Intraoperative C-arm fluoroscopy, as compared to IGS, is more straightforward and cheaper, and can provide real-time feedback about surgical anatomy. Furthermore, a surgeon can decide to use this system during surgery, and there is no registration error. However, other structures surrounding sinuses and limitation of C-arm resolution mean that intraoperative C-arm fluoroscopy may be of little help during procedures on sinuses, other than the frontal sinus. However, the clinical utility of intraoperative C-arm fluoroscopy for frontal sinusotomy may be considerable, because frontal sinusotomy is a difficult procedure and prone to many complications. Therefore, we consider that intraoperative C-arm fluoroscopy can importantly complement IGS during ESS.

Conclusion

Intraoperative C-arm fluoroscopy can be used for the frontal sinusotomy in patient with paranasal sinusitis whose frontal recess anatomy is complicated by various reasons. Limitation of this system is that it cannot be of

help to the procedures of the other sinuses than frontal sinus. Intraoperative C-arm fluoroscopy, therefore, can be complementary to IGS during ESS.

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