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ORIGINAL ARTICLE

# Improved Planning of Endoscopic Sinonasal Surgery From 3-Dimensional Images With Osirix® and Stereolithography☆

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**KEYWORDS**
Virtual reality;
Three-dimensional imaging;
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**Abstract**
*Introduction and Objectives:* The high variability of sinonasal anatomy requires the best knowledge of its three-dimensional (3D) conformation to perform surgery more safely and efficiently. The aim of the study was to validate the utility of Osirix® and stereolithography in improving endoscopic sinonasal surgery planning.
*Methods:* Osirix® was used as a viewer and Digital Imaging and Communications in Medicine (DICOM) 3D imaging manager to improve planning for 114 sinonasal endoscopic operations with polyposis (86) and chronic rhinosinusitis (CRS) (28). Stereolithography rapid prototyping was used for 7 frontoethmoidal mucoceles.
*Results:* Using Osirix® and stereolithography, a greater number of anatomical structures were identified and this was done faster, with a statistically-significant clinical–radiological correlation ($P<.01$) compared with 2D CT plates. With a share of more than 75% of surgery performed by residents, surgical time was reduced by $38 \pm 12.3$ min in CRS and $42 \pm 27.9$ in sinonasal polyposis. The fourth-year residents reached 100% surgical competence in critical surgical milestones with 16 surgeries (CI 12–19).
*Conclusions:* The systematic use of Osirix® for visualisation and treatment of 3D sinonasal images from DICOM data files, along with the surgical team's ability to manipulate them as virtual reality, allows surgeons to perform endoscopic sinonasal surgery with greater confidence and in less time than using 2D images. Residents also achieve surgical competence faster, more safely and with fewer complications. This beneficial impact is increased when the surgical team has stereolithography rapid prototyping in more complex cases.


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**PALABRAS CLAVE**
Realidad virtual;
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Planificación quirúrgica

**Mejora de la planificación de las cirugías endoscópicas nasosinusales a partir de imágenes en 3 dimensiones con Osirix® y estereolitografía**

**Resumen**
*Introducción y objetivos:* La elevada variabilidad anatómica de los senos paranasales requiere disponer del mejor conocimiento de su conformación tridimensional para afrontar la cirugía con mayor seguridad y eficiencia. El objetivo del estudio fue validar la utilidad de Osirix® y la estereolitografía en la mejora de la planificación de las cirugías endoscópicas nasosinusales.
*Métodos:* Se utilizó Osirix® como visor y gestor de imágenes DICOM en 3 dimensiones (3D) en la planificación de 114 cirugías endoscópicas nasosinusales por poliposis (86) y rinosinusitis crónica (28) junto con prototipos rápidos estereolitográficos en 7 mucoceles frontoetmoidales.
*Resultados:* Se identificaron mayor número de estructuras anatómicas, más rápidamente y con una correlación clínico-radiológica estadísticamente significativa ($p < 0,01$) a favor de Osirix y estereolitografía, que con placas en 2D de la TAC. Con una participación de los residentes superior al 75% de la cirugía, se redujo el tiempo quirúrgico en $38 \pm 12,3$ min en sinusitis crónicas y en $42 \pm 27,9$ en poliposis nasosinusales, alcanzando los residentes de cuarto año una competencia quirúrgica del 100% en los hitos quirúrgicos cruciales con 16 cirugías (IC: 12-19).
*Conclusiones:* La utilización sistemática de Osirix® para visualización y tratamiento autónomo de imágenes nasosinusales en 3D desde archivos DICOM permite a los cirujanos efectuar las cirugías endoscópicas nasosinusales con mayor confianza y seguridad y en menos tiempo que utilizando imágenes en 2D. Los residentes también alcanzan la competencia quirúrgica más rápidamente, con mayor seguridad y con menos complicaciones. La mejora en la planificación se incrementa cuando el equipo quirúrgico dispone de prototipos rápidos estereolitográficos en los casos de mayor complejidad.


## Introduction

Planning the execution of sinonasal endoscopic surgery requires knowing, before the intervention, the shape and placement of the sinonasal structures as precisely as possible. Its objective is treating the disease completely, avoiding complications and not causing failed surgeries.[1] The elevated inter-individual variability of sinonasal anatomy has been the objective of many publications that attempt to made its own anatomy and its nomenclature more precise, as well as identifying the structures through X-ray images.[2] The 3-dimensional (3D) configuration of the anatomical elements makes it necessary for surgeons to carry out a complex psychological and neurological process[3] to interpret the 2-dimensional (2D) images from computed axial tomography (CAT) scans or nuclear magnetic resonance (NMR) studies. Surgeons have to prepare a speculative recreation of normal sinonasal anatomy and of the altered anatomy of the lesion to operate, as well as its relationship with the other anatomical structures and between them. Recent, widely disseminated texts attempt to help the surgeons in the task of planning sinonasal endoscopic surgery based on imaginative formulas that help them to interpret 2D X-ray images in 3D.[4]

Imaging diagnostic services attempt to facilitate this mental process by proving 2D images in conventionally standardised space planes. Technological evolution is substituting the image selection of the radiologist in hospital reds that allow clinicians access, from specific visors or from computers located in surgeries or operating theatres, to the complete file of digital imaging and communication in medicine (DICOM) images with the ''.dcm'' extension. Nevertheless, information oriented towards surgery still remains insufficient.[5] Intraoperative surgical navigators (computer assisted surgery) make 3D reconstructions of the DICOM images. They provide simultaneous multi-plane vision in 2D combined with the endoscopic image,[6] but they require carrying out these tasks within the operating room.

In April 2004, Osirix® (Pixmeo, Switzerland) appeared. This is an open-code program developed by Rosset et al. that transforms an Apple Macintosh® computer into a DICOM workstation to process and visualise medical images from multiple source (NMR, CAT, PET, PET-CAT, SPECT-CAT, ultrasound, etc.).[7,8] The program is distributed under a GNU-type license, and its code is available openly, without cost and freely.[9] Osirix offers high reliability, admitting a maximum accuracy error of 0.3 mm.[10] The surgeon can dynamically and simultaneously visualise all the cuts, displacing the cross point of the axes to any position desired. Surgeons can take lineal, area and volumetric measurements and perform the 3D reconstructions considered the best. This all happens autonomously, even outside of the operating theatre, in surgeries or meeting rooms and classrooms, recording selections of the work in images or videos. Consequently, the loss of information generated in the process of radiological printing or vision through static cuts is eliminated.

An ideal method of obtaining 3D perception of the structures is based on the disposition of artificial models that simulate the real model to the maximum extent possible, fulfilling a function similar to that of the scale-size models