



# Use of three-dimensional virtual images for planning surgery of complex anal fistulas: a new technology available via smartphone

E. C. Sousa Júnior<sup>1</sup> · W. M. N. Eulálio Filho<sup>2</sup> · A. T. Nogueira<sup>3</sup> · B. A. Rocha<sup>4</sup> · A. D. Meneses<sup>5</sup>

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## Introduction

Treatment of complex anal fistulas is considered a challenge for most surgeons. Although many surgical techniques are available, it is very important to identify fistula tracts before and during the surgical procedure [1]. Therefore, technologies should be developed to improve preoperative planning. As a result, the best surgical approach will be chosen, and proper healing of the perianal region will be optimized.

In the past few years, several specialties have benefitted from three-dimensional (3D) patient-specific anatomical models to diagnose diseases and plan complex operations. However, there are only few reports describing the use of new technologies for planning rectal and anal surgery [2–5]. The aim of this study was to describe the process of creating a 3D image from patient anatomy. It also addresses preoperative surgical planning for the correction of complex anal fistulas using magnetic resonance imaging (MRI) through access by smartphone or tablet.

## Clinical case

We present the case of a 41-year-old man with a complaint of perianal pain for 6 months after urgent drainage of an anorectal abscess. Proctologic examination revealed a surgical scar in the left anterior quadrant. Palpation and rectal

examination detected two fistula tracts in the anterior quadrants (Fig. 1). Colonoscopy was normal. The diagnosis was idiopathic fistula. MRI showed two complex anterior anoperineal fistula tracts, with bilateral anterior paramedian primary orifices, an anterior perineal path and formation of collections located inferior to the body of the penis, measuring 2.1 cm × 1.1 cm on the left and 2.6 cm × 1.5 cm on the right (Fig. 2). After clinical and radiological diagnoses, surgical treatment was indicated and the patient agreed to participate in the project and gave written informed consent.

## Methods of reconstruction

Initially, an MRI was performed on a Magnetom Avanto 1.5 T device (Siemens Medical System; Erlangen, Germany), following the standard protocol of our institution for perianal fistulas, which included T2-weighted sequences in the axial, coronal (with an angulation for the anal canal) and sagittal planes, as well as T1-weighted post-contrast sequences, STIR and diffusion sequences, with 3-mm-thick slices. The images were exported to Vitrea fX Workstation® software (Vital Images Corporation—Toshiba Medical Images)®. An experienced radiologist analyzed and performed image segmentation. Segmentation was aimed at identifying the following anatomical structures: anal canal, levator ani musculature (external anal sphincter), internal anal sphincter muscles, and fistula paths (including internal and external orifices).

After segmentation, the images were sent in a CAD-compatible format (.STL) to a 3D image processing software (Meshlab v. 1.3.3—ISTI—CNR Research Center, Pisa University, Italy). Colors were assigned to different anatomical structures to facilitate identification. Fistula paths were displayed in yellow, levator ani muscles in brown, and the rectum in green (Fig. 3). The final 3D colored model enabled the control of rotation, zoom use, and selection of any 3D object, individually or grouped.

✉ W. M. N. Eulálio Filho  
walberto@outlook.com

<sup>1</sup> Department of General Practice, Discipline of Surgical Clinic, Federal University of Piauí, Teresina, Brazil

<sup>2</sup> Federal University of Piauí, Teresina, Brazil

<sup>3</sup> InfiniBrains, São Paulo, Brazil

<sup>4</sup> Radiology Department - Hospital das clínicas, USP Medical School, São Paulo, Brazil

<sup>5</sup> Urology Department, São Marcos Hospital, Teresina, Brazil

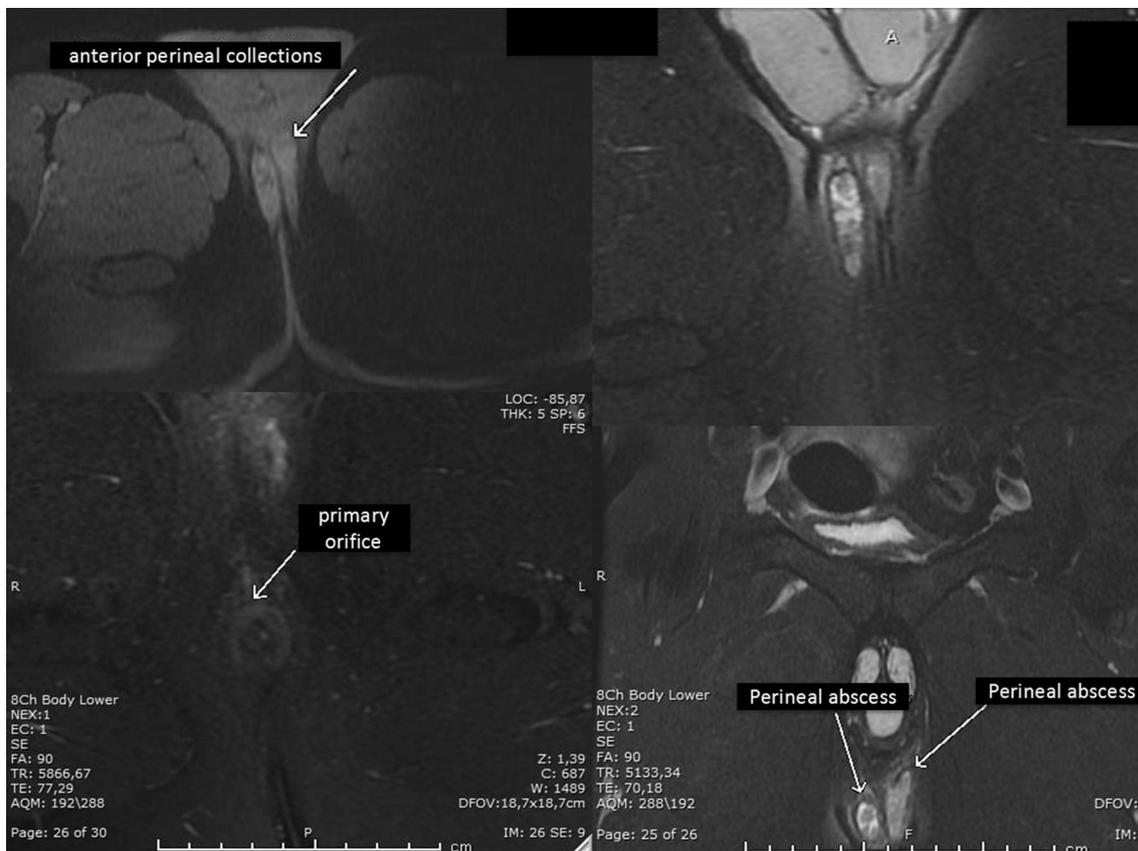


**Fig. 1** Preoperative photograph

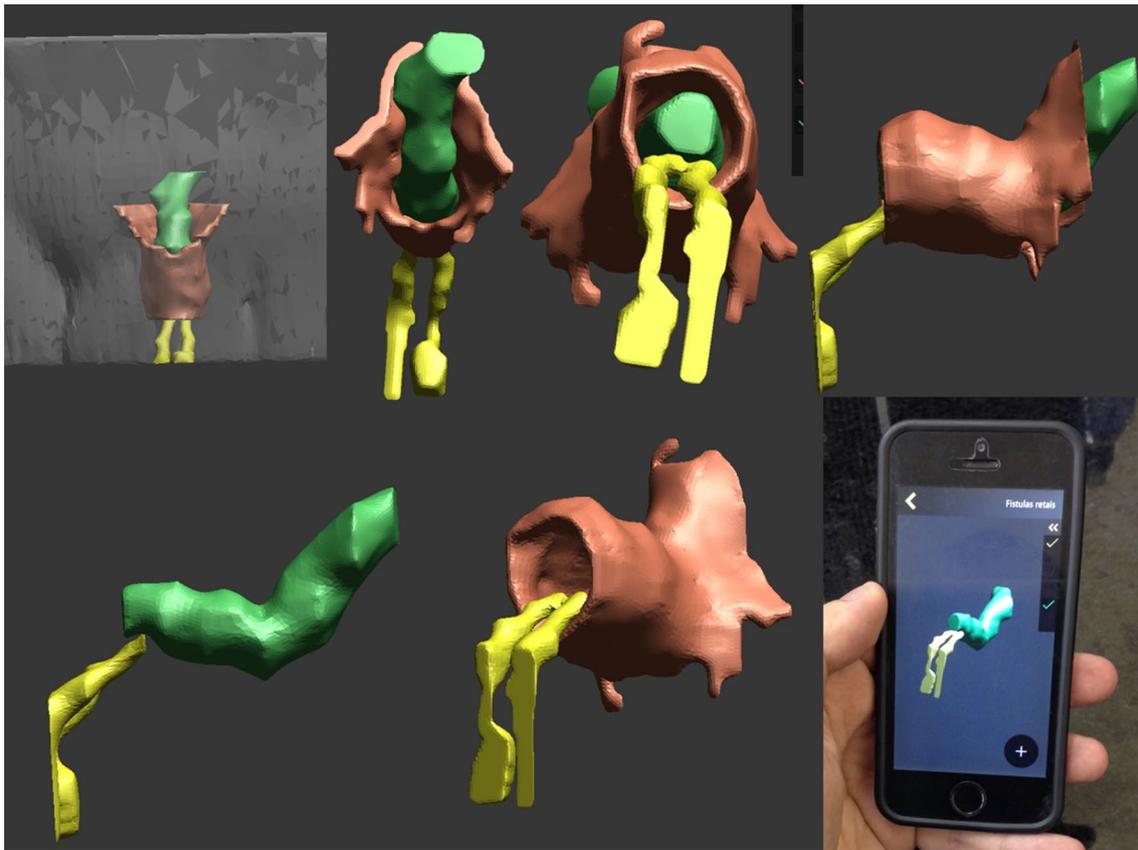
This model was accessed by the surgical team through a smartphone app developed by our team to provide quick and simple access before and during surgery. The software was tested in the preoperative period and applied during surgery, in the intraoperative stage, for guidance of the surgeon through both cannulation of the fistula tracts/internal orifice and for the identification of adjacent structures.

## Surgical procedure

Cannulation of fistula tracts was performed with the patient under pudendal block. Bilateral fistulotomy was performed (Fig. 4) and firmly tied elastic seton placed where the fistula crossed the sphincters, which cut out spontaneously on the 12th postoperative day. Operating time was 100 min. The patient was discharged on the second postoperative day, reporting mild local pain. During outpatient follow-up of 8 months there were no signs of local fistula recurrence or abscesses (Fig. 5).



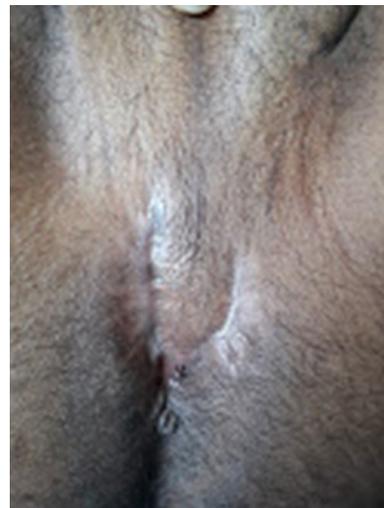
**Fig. 2** Magnetic resonance imaging showing two complex anterior anoperineal fistula tracts, with anterior paramedian primary orifices bilaterally, with the formation of an anterior perineal path and of collections located inferior to the body of the penis



**Fig. 3** Final three-dimensional colored model and its visualization by smartphone. Fistula paths are displayed in yellow, levator ani muscles in brown, and the rectum in green



**Fig. 4** Dissection and exposure of one fistula tract



**Fig. 5** End result 2 months after surgery

## Discussion

It is undeniable that the use of 3D reconstruction for preoperative surgical planning in various surgical procedures in recent years has been advantageous. There are few reports

of the use of this technology for the treatment of complex anal fistulas. In addition to our early experience published in 2018, some other centers have also used this approach, with very promising initial results [2, 3]. Of these, the

most experienced is an Australian group that performed reconstruction of ten cases of fistulizing Crohn's disease by adding a 3D T2-weighted sequence to the existing MRI protocol at that institution [2]. The other group described only 1 case of complex anal fistula reconstruction with a methodology similar to that described in this article [3]. In both studies, the quality of model images was limited, although both provided surgeons with a proper anatomical analysis. Furthermore, easy access by smartphone or tablet enables the surgical team to analyze images intraoperatively. Thus, surgeons are able to compare previous examinations with patient anatomy to address any potential doubts that may arise during the procedure.

Recently, some surgeons have begun to work with 3D printing of anal fistula models. This is a new technology that continues to evolve. Despite providing similar information for surgical planning, physical model printing may be helpful in the discussion with the patient about the need for surgery, the surgical approach and complications that may potentially result from the procedure [4, 5]. Moreover, the high cost of 3D printing equipment may limit the use of this technique in settings of limited financial resources. However, it is a good alternative for surgery residency training since it allows pre-simulation of the surgical steps according to specific patient anatomy [5].

Although this was a pilot project, the result was satisfactory since we created an accessible and inexpensive way to analyze in mobile platforms 3D images which previously could only be visualized in computers, without loss of image quality. In this case, image processing costs approximately 200 US dollars. We used an application developed a few years ago by another hospital team which can be downloaded for free and is accessible to all physicians and patients.

## Conclusions

3D virtual reconstruction of complex anal fistulas on accessible platforms, such as the smartphone, facilitates surgical planning. Moreover, the tool makes possible anatomical assessment and its correlation with imaging during surgery.

## Compliance with ethical standards

**Conflict of interest** The authors declare that they have no conflict of interest.

**Ethical approval** All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

**Informed consent** The patient involved in this case was appropriately consented for this publication using the institution's policy for media consent.

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