Stereotactic navigation in orbital decompression surgery – Does it shorten operative time and improve outcomes?

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Abstract:

PURPOSE: Stereotactic navigation is being increasingly used for orbital decompression (OD). Recent studies have cited clinical benefits of navigation including greater proptosis reduction but have differed regarding effects on operative time. This study aimed to evaluate navigated vs. non-navigated OD with respect to operative time and proptosis reduction.

MATERIALS AND METHODS: Retrospective nonrandomized comparative trial of navigated vs. nonnavigated OD. Operative time and proptosis reduction were recorded and analyzed for all patients.

RESULTS: A total of 30 orbital decompressions were included; 14 were performed with stereotactic navigation (SN), and 16 were performed without SN. On average, the SN group took 19 minutes longer for 3-wall decompressions (p = 0.185), 25 minutes shorter for balanced decompressions (p = 0.025), and 18 minutes longer (p = 0.067) for lateral wall decompressions. Mean proptosis reduction (PR) in 3-wall decompressions was greater in the SN group (p = 0.02). Among balanced wall decompressions, mean PR was 4.25 mm and 3.67 mm for the SN and non-SN groups (p = 0.30), respectively. For lateral wall decompressions, mean PR was 2.63 mm with SN and 2.50 mm without SN (p = 0.45).

CONCLUSIONS: This study showed no difference in operative times between navigated and non-navigated OD, although empirical experience showed variable times required for registration and intraoperative troubleshooting of the navigation system. This study also found that navigation increased proptosis reduction for all types of OD. Further randomized controlled trials are needed to better understand the impact of navigation technology on operative times and surgical outcomes.

Keywords:

Operative time, orbital decompression, proptosis reduction, stereotactic navigation, thyroid associated ophthalmopathy, thyroid eye disease

Introduction

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Thyroid eye disease (TED) can cause disfiguring proptosis, exposure keratopathy, and in more severe cases, compressive optic neuropathy. Orbital decompression (OD) is an important treatment option for TED but can be a challenging surgical procedure due to the need for complex three-dimensional (3D) understanding of the orbit and its surrounding structures, proximity to the intracranial space, limited visualization, and potential anatomical variation. Detailed patient-specific anatomic knowledge can assist in preventing serious complications, including cerebrospinal fluid leakage, meningitis, orbital hematoma, nerve injury, and other iatrogenic complications.[1]

With the introduction of computer-assisted surgery, stereotactic navigation (SN) has been utilized to provide intraoperative 3D localization of anatomical structures. This is particularly helpful for surgical

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procedures that involve complex spatial anatomy such as the orbit and paranasal sinuses. Utilizing the patient's preoperative imaging, SN enables visualization of patient-specific anatomy in real-time intraoperatively during OD.[1-8] While there has been limited outcomes research on SN for OD, previous studies have discussed the theoretical benefits of SN such as enabling surgeons to orient themselves to important landmarks, confirm the extent of bone removal, determine the maximal limits of decompression, and minimize iatrogenic injury.[2,4] Limited studies in the literature suggest that SN increases postoperative proptosis reduction (PR) and can improve strabismus outcomes.[3,6]

In spite of its potential advantages, the use of SN technology requires time for set-up, registration, and trouble-shooting calibration issues that can potentially prolong operative time and expenses.[4,6] Only a few studies have examined the impact on surgical time using SN in OD. While one study showed that SN resulted in shorter operative times and did not impact nonoperative time spent in the OR, another recent paper showed that the use of SN prolongs total surgical time.[3,6]

Given the potential benefits of this technology and limited existing evidence of its clinical benefit, this study aimed to evaluate the effect of intraoperative SN on operative time and PR in OD by a single surgeon at an academic institution.

Materials and Methods

The study was approved by the University of Miami Institutional Review Board (approval number: 20170499). The authors retrospectively reviewed clinical data of all patients with TED who received OD with the senior author (B. W. L.) between December 2015 and January 2020.

Parameters evaluated included patient age, gender, laterality, use of a navigation system (Medtronic Stealth Station ENT Navigation), decompression technique and surgical approach, presence of a trainee, pre and postoperative Naugle exophthalmometer measurements, and total operative time. All patients who underwent navigation-guided surgeries received appropriate preoperative computed tomography images of the orbital region. Operative time was defined as the total minutes from procedure start to procedure finish, including SN patient registration as well as preoperative and intra-operative trouble shooting of any calibration issues.

All cases included underwent standardized surgical approaches and techniques for three-wall decompression, "balanced" lateral and medial wall decompression, or lateral wall decompression (For cases included in the study, the standard 3-wall decompression technique involved a lateral lid crease approach for the lateral wall. The medial wall and floor were addressed through contiguous transconjunctival and transcaruncular incisions with disinsertion and subsequent reinsertion of the inferior oblique muscle. Other 3-wall decompressions for which the floor and medial wall were addressed through a single transcaruncular incision without disinsertion and reinsertion of the inferior oblique were not included in this study. The standard "balanced" decompression technique involved a lateral lid crease approach and transcaruncular approach to the medial wall. Other non-"balanced" 2-wall decompressions (e.g., floor and medial wall) and balanced decompressions in which an additional transconjunctival incision was made with disinsertion of the inferior oblique were excluded). Cases for which surgical technique deviated from standard surgical approaches were excluded. Additional exclusion criteria included inadequate OR timing records, revision ODs, simultaneous bilateral surgeries, and cases in which two or more surgical trainees were involved.

Two groups were created from the data points: OD with SN and OD without SN. Primary outcomes were operative time and PR. Operative times for cases in which additional surgeries were performed simultaneously, such as eyelid retraction repair, blepharoplasty, or other esthetic procedures were excluded. Statistical tests were performed based on a one-tailed t-test. Statistical significance was based on $P < 0.05$.

Table 1: Patient and decompression characteristics

	Navigated	Nonnavigated
Number of OD	14	16
Age (years)	46	52
Percentage female	86	88
Decompression technique (%)		
3-wall	43	37
Balanced	29	19
Lateral wall	29	44

OD: Orbital decompression

Table 2: Average operative time and proptosis reduction for navigated versus nonnavigated orbital decompression

	Navigated	Nonnavigated	Difference	P
Mean OT (min)				
3-wall	178	159	+19	0.185
Balanced	110	135	−25	0.025
Lateral wall	106	88	+18	0.067
PR (mm)				
3-wall	6.25	4.67	+1.58	0.02
Balanced	4.25	3.67	+0.58	0.30
Lateral wall	2.63	2.50	+0.13	0.45

PR: Proptosis reduction, OT: Operative time

Results

A total of 67 ODs were reviewed between 2015 and 2020. Based on the inclusion and exclusion criteria, a total of 30 ODs were included [Table 1]. Of the 30 ODs, 14 were performed with SN, and 16 were performed without SN. The mean age was 46 and 52 years old in the SN and non-SN groups, respectively. Both groups were predominantly female. Within the SN group, six patients (43%) underwent 3-wall decompression, four patients (29%) underwent balanced wall decompression, and four patients (29%) underwent lateral wall decompression. Within the non-SN group, six patients (38%) underwent 3-wall decompression, three patients (19%) underwent balanced decompression, and seven patients (44%) underwent lateral wall decompression.

Operative time (minutes) and PR (millimeters) were calculated in each group and subcategory [Table 2]. Within the SN group, mean operative times for 3-wall, balanced, and lateral wall decompression were 178, 110, and 106 min respectively. In the non-SN group, mean operative times for 3-wall, balanced, and lateral wall decompression were 159, 135, and 88 min. While there was no statistically significant difference between the SN and non-SN subcategories for operative times, the SN group took an average of 19 min longer for 3-wall decompressions ($P = 0.185$), 25 min shorter for balanced decompressions ($P = 0.025$), and 18 min longer ($P = 0.067$) for lateral wall decompressions. A sub-analysis of cases performed without any surgical trainees involved showed a general trend of SN being associated with longer operative time. In the attending-only sub-analysis, 3-wall decompressions had mean operative times of 168 min and 162 min for the SN ($n = 3$) and non-SN ($n = 4$), respectively ($P = 0.43$).

Mean PR in 3-wall decompressions was greater in the SN group (6.25 mm) compared to the non-SN group (4.67 mm) ($P = 0.02$). Among balanced wall decompressions, mean PR was 4.25 mm and 3.67 mm for the SN and non-SN groups ($P = 0.30$), respectively. Finally, for lateral wall decompressions, mean PR was 2.63 mm with SN and 2.50 mm without SN ($P = 0.45$).

Discussion

SN is a promising technology that is increasingly being used for OD, but there are limited outcomes data available in spite of theoretical benefits. While there have been studies suggesting that intraoperative SN can improve surgical outcomes, biases such as financial disclosure should be considered and the presence of commercial interested between study authors and companies raise the question of such potential bias.[3,6,8,9]

We sought to study two particular study outcomes, operative time and PR, for OD with and without SN.

Studying the effect of SN on the time spent in the OR is complicated because time is involved to setup the technology, upload preoperative scans, perform patient registration and surface mapping, and then troubleshoot any accuracy issues. Then, there is the actual time spent performing the surgery with the technology. In the authors' experience, setting up the technology and uploading preoperative scans can be performed simultaneously during induction of general anesthesia, but patient registration, surface mapping, and trouble shooting is additional time spent by the surgeon when the surgery could already have started. For this reason, we considered these steps as part of the operative times. Considering these timing complexities, there are conflicting reports regarding the impact of intraoperative SN on total surgical time for OD.[3,6] Heisel et al. found that SN reduced operative time (125.8 min in SN group vs. 141.3 min in non-SN group). However, the study included both unilateral and bilateral surgeries, and two unilateral operative times were derived by dividing bilateral operative time in 2 (in spite of shared setup and registration times). Furthermore, the type of surgical procedure was loosely defined, as some cases categorized as "balanced" decompressions further included posterior orbital floor decompression.[3] Grouping cases together for which different surgical techniques were used can limit the accuracy and interpretability of data.[10] A different study found that SN use was associated with an average increase of 40 min of total operative time. However, this study included surgical cases performed by multiple attending surgeons without a standardized surgical approach and technique.[6] Finally, neither study addressed the involvement of trainees, which can greatly affect surgical time.[10]

In this study, while SN resulted in a significantly shorter operative time for balanced OD, there was no significant difference for lateral and 3-wall decompressions and in fact, mean operative times were longer in the latter two groups. In a small subgroup analysis of 3-wall only decompressions in which no trainees were involved in the surgery, the overall operative time was longer when the attending surgeon used SN for 3-wall decompressions. Analysis for lateral and balanced decompressions was not practical in the attending-only subgroup analysis due to limited numbers. The involvement of different trainees at an academic teaching institution certainly affects operative time, as does the amount of time the attending surgeon allows trainees to act as primary surgeon. A trainee's familiarity with the technology and experience performing OD also determines how much time is spent intraoperatively using the SN for orientation and to identify landmarks. This further adds to the complexity of studying SNs effect on operative time.

Regarding PR, this study supports previous studies' findings that SN results in enhanced PR. This was most pronounced for 3-wall decompressions with SN use associated with an additional 1.58 mm of PR ($P = 0.02$). Although it did not achieve statistical significance, SN use was associated with greater PR for balanced (0.58 mm) and lateral wall (0.13 mm) decompression groups, respectively. If the surgeons feel the SN device is both accurate and reliable during the surgery, the technology likely gives surgeons greater comfort in pushing the anatomical endpoints of OD surgery and thereby achieving larger decompressions and greater PR.

Limitations of the study include the small sample size, trainee involvement, learning curve for SN set up, and the use of different registration and calibration techniques when trouble shooting accuracy issues. It is important to note that there may be a learning curve when adopting a new technology. While our data did not reflect a learning curve, it is important to consider that there were different surgical trainees involved for the majority of cases despite having the same attending surgeon. To standardize surgical approach for the analysis of operative time, several cases had to be excluded, limiting the number of cases in each subcategory. Future studies with larger numbers of cases without trainee involvement would be useful to further study how SN impacts operative time and PR.

Conclusion

Our study suggests that SN does not have a significant benefit in reducing operative times across different types of OD surgeries. However, SN was associated with significantly more PR for 3-wall decompressions and trended toward greater PR for lateral and balanced decompressions. Additionally, it can be a useful educational tool to improve confidence and minimize stress for novice surgeons in orbital surgery.[1,4] Further studies are needed to help understand whether the theoretical benefits of this technology translate into improved clinical outcomes, operative times, and surgical education.

Conflicts of interest
The authors declare that there are no conflicts of interest of this paper.

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