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ORIGINAL ARTICLE

Retroauricular endoscopic and robotic versus conventional neck dissection for oral cancer

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Abstract There has been a significant increase in concern towards improving aesthetic and functional outcomes without compromising the oncologic effectiveness in head and neck surgery. The aim of the current study is to assess the feasibility and oncological outcome of the retroauricular approach for endoscopic and robot-assisted selective neck dissection (SND) for oral cancer in comparison with the conventional SND. A retrospective single institute cohort study was designed. Patients undergoing an SND for oral cavity carcinoma were included and allocated into two groups: (1) retroauricular approach group for endoscopic-assisted or robot-assisted SND or (2) transcervical approach group for the conventional SND. Primary endpoint was the perioperative and postoperative treatment outcomes. Secondary endpoint was the early oncologic outcome. Sixty patients were included (17 retroauricular; 43 conventional). For the primary outcome, only a significant longer operative time in the retroauricular group was identified. No unintentional injury or conversion to the conventional surgery was recorded. There was no significant difference identified in the early oncologic outcome, including number of retrieved lymph nodes and disease-free survival. Postoperative aesthetic results were considered superior when subjectively compared to the conventional approaches. Endoscopic and robot-assisted SND via a retroauricular approach is feasible, safe, and oncologically efficient when compared with the conventional surgery in a short follow-up scenario. It can be used for selected cases with a clear cosmetic benefit. However, further research with longer follow-up and patient satisfaction analysis is mandatory.

Keywords Neck dissection · Oral cancer · Oral carcinoma · Video-assisted surgery · Robotic surgery

Introduction

In recent years, oncologic surgery has been making remarkable progress to improve functional outcome while maintaining oncologic safety. Especially technological advances in endoscopic and robot-assisted procedures have made a considerable contribution by facilitating less and even minimal invasive approaches. Studies have not only demonstrated potential improvements in oncological outcome by using these techniques, but also better functional outcome, minimal morbidity, and an increased health-related quality of life [1, 2]. Therefore, many of these procedures are now clinically applied within several surgical subspecialties, including head and neck surgery [3].

Head and neck surgery is characterized by a complex anatomy and manipulation of delicate and important structures in frequently difficult accessible and visualized areas. Due to various concerns of exposure and visualization, many head and neck surgeons remain hesitant to use minimal invasive techniques. This would suggest that the majority of patients are still submitted to extensive open surgical approaches, resulting in different degrees of aesthetic and functional sequelae, which itself might be associated with psychosocial repercussions [4]. Therefore,

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despite the earlier mentioned obstacles and concerns, there is a continuous desire to investigate and explore new indications for the minimal invasive techniques in head and neck surgery, such as selective neck dissection [3, 5].

The wish to limit aesthetic and psychological consequences has also driven the development of different remote access approaches to the neck [6–15]. Due to limitations of certain approaches, such as the transaxillary access, an alternative approach via the retroauricular access has been introduced [6, 10, 12–14, 16–21]. Proponents advocate that this technique should lead to reduction of postoperative complications, better cosmetic results, similar oncologic outcome (number of retrieved lymph nodes), and decreased risk of exposure of large cervical vessels in case of flap necrosis or dehiscence [9–11, 13, 14, 22].

Up till now, there is only limited evidence available on endoscopic and robotic neck dissection via a retroauricular approach. Yet, before broad clinical implementation, the feasibility of these procedures has to be carefully and objectively assessed together with the oncological outcome. In addition, complications should be taken into consideration, as new potential complications have been described [5, 23, 24]. Thereafter, the actual reduction of functional and cosmetic morbidity (e.g., large visible neck scars) has to be evaluated, as well as costs, as economic viability may limit the use on a larger scale [3]. Depending on financial resources, alternative use of video-assisted endoscopic techniques instead of robot-assisted techniques might be a more feasible option to optimize aesthetic and functional outcomes [22].

The aim of the current study is to retrospectively assess the feasibility and oncological outcomes of the retroauricular approach for endoscopic and robot-assisted selective neck dissection (SND) in a single institute cohort undergoing treatment for oral cancer and compare these results to the conventional SND.

Materials and methods

Study design

A retrospective cohort study was designed. The cohort consisted of all patients with an oral cavity carcinoma (OCC) who underwent a selective neck dissection (SND) as part of the primary treatment from July 2014 to October 2015 at the Department of Head and Neck Surgery and Otorhinolaryngology of the AC Camargo Cancer Center, São Paulo, Brazil. All eligible patients had a histology confirmed diagnosis by biopsy or local excision from the primary site and were clinically staged by radiologic examination and fine needle aspiration cytology (FNAC) if indicated. Patients with bulky neck disease (cN3), a primary tumor extending to the adjacent neck compartment, distant metastasis (cM1), or a history of previous neck surgery were excluded from the study.

Depending on the primary predictor variable of this study, the surgical approach, patients were allocated into two groups: (1) the retroauricular approach group for either endoscopic-assisted or robot-assisted SND or (2) the transcervical approach group for the conventional SND.

Surgical technique

Retroauricular approach

For both the endoscopic-assisted and robot-assisted SND, a retroauricular approach was performed as previously described by the Yonsei Medical Center in Seoul [12, 13, 25]. Following retroauricular skin incision, skin flap is dissected just below the platysma muscle providing exposure of the neck levels to be dissected. The next step is to dissect level II and III, from lateral to medial, starting with conventional instruments and a head light, very similar to the transcervical approach. All dissection lateral to the carotid artery is performed with a direct view. Following, for dissection medial to the carotid artery, Bookwalter Retractor® is placed keeping the skin flap raised and video-assisted or robotic dissection is performed finishing levels II–III and then dissecting level I (Fig. 1).

Transcervical approach

The conventional SND via a transcervical curvilinear skin incision along a natural skin crease was performed accordingly to established surgical techniques.

For all three approaches, the SND was conducted by dissection of the lymphoadipose tissue in the desired levels with preservation of the marginal mandibular branch of the facial nerve and the vagal, hypoglossal lingual, spinal accessory, and phrenic nerve (Fig. 2).

Data acquisition and analysis

Electronic medical charts were reviewed. Demographic and clinicopathological characteristics data were recorded. Perioperative and postoperative treatment outcomes of the patients up to the first postoperative month, total number of lymph nodes (LN) retrieved, adjuvant therapy, and disease-free survival (DFS using follow-up time and disease status) were evaluated and compared.

Besides descriptive analysis, statistical comparison between the different surgical groups was computed as

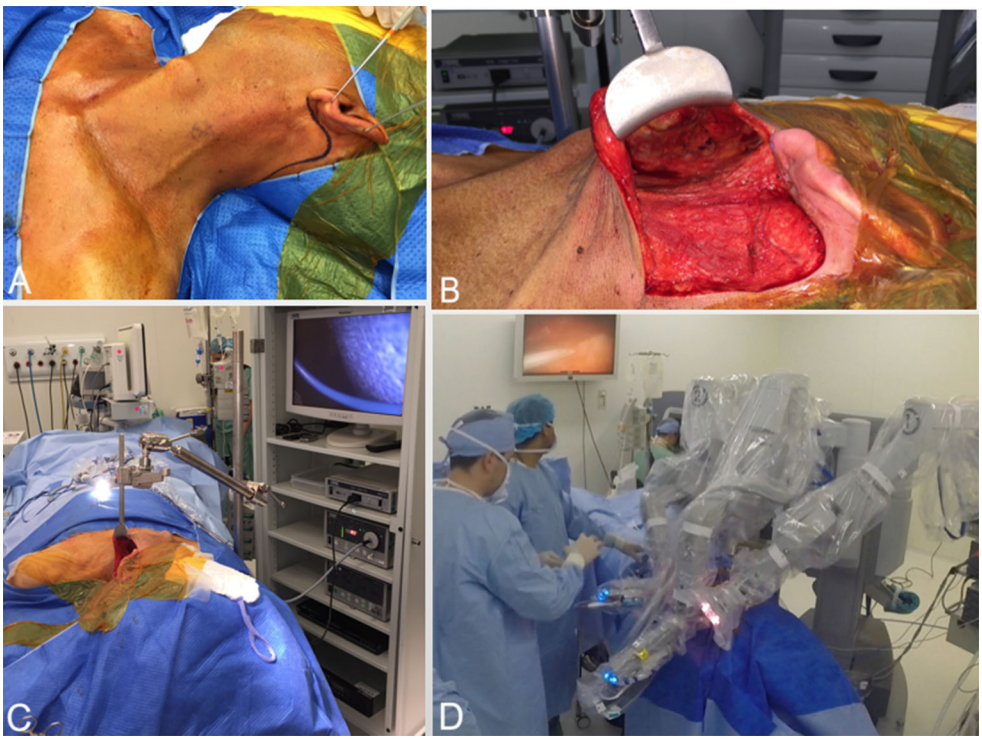

Fig. 1 **a** Retroauricular incision design. **b** Working space for neck dissection. **c** Setup for endoscope-assisted neck dissection. **d** Setup for robotic-assisted neck

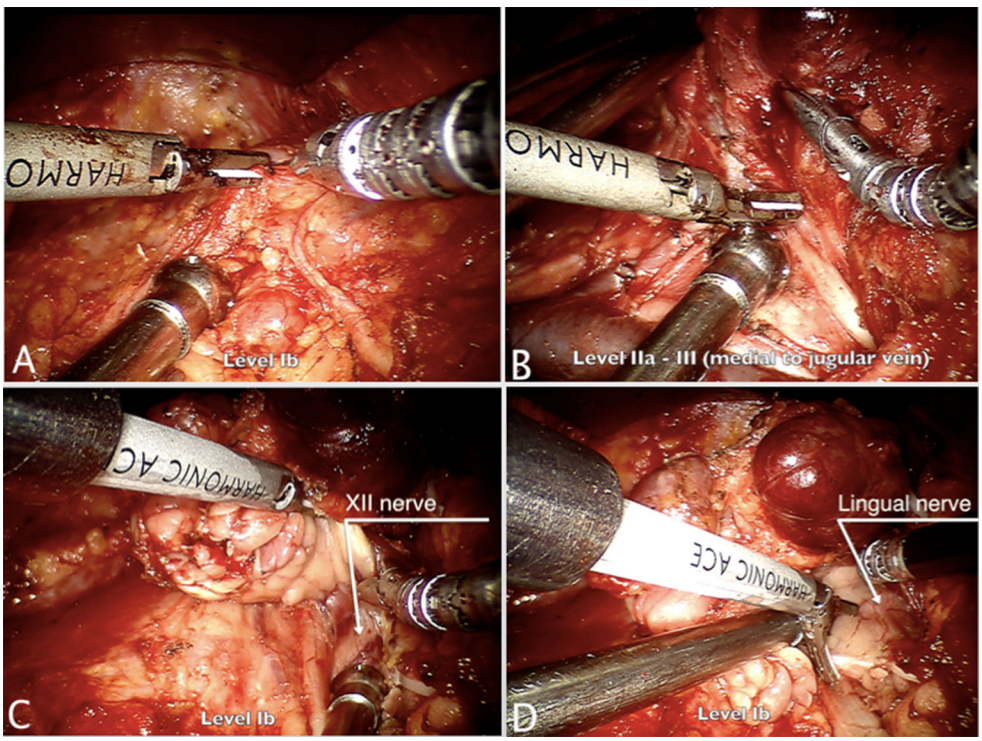

Fig. 2 Robotic neck dissection (left side - levels I–III). **a** Level Ib: dissection of marginal branch. **b** Level IIa: dissection of XII nerve and internal jugular vein. **c** Level Ib: dissection of XII nerve. **d** Level Ib: dissection of lingual nerve0

well as correlations between variables using the Chi-square test and two-tailed Fisher exact test for categorical data and the Mann–Whitney *U* test for continuous data. Survival analysis was done using the Kaplan–Meier method and log-rank test. Probabilities of less than 0.05 were considered statistically significant.

The study was approved by the local institutional review board.

All procedures followed were in accordance with the ethical standards of the responsible committee on human experimentation (institutional and national) and with the Helsinki Declaration of 1975, as revised in 2000 (5). Informed consent was obtained from all patients for being included in the study.

Results

Sixty patients were identified and included in the study. Patients were clinically staged as cT1N0M0 to cT4N2cM0. In total, 43 underwent a conventional approach for the SND and 17 underwent a retroauricular approach for 11 endoscopic-assisted and 6 robotic-assisted SND (Fig. 3).

Conventional approach

Forty-three patients were submitted to a conventional SND via a conventional approach, of which 27 (62.8%) were male. The mean age at diagnosis was 58 years (range 29–85) and the mean BMI was 24.3 kg/m^2 (range 18–40).

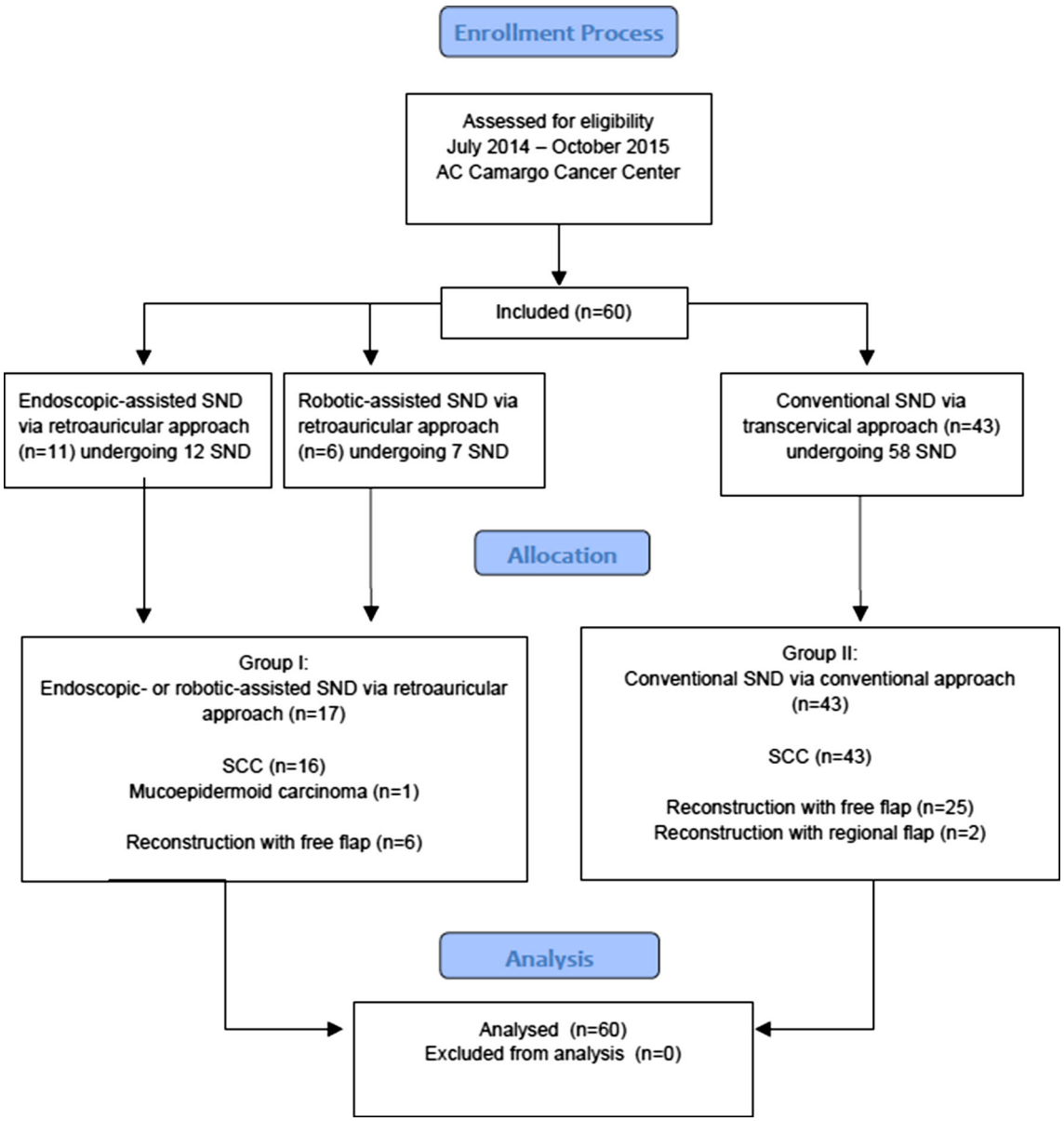

Fig. 3 Consort diagram

Table 1 Clinical and pathological information

Characteristic	Conventional ($N = 43$)	Retroauricular ($N = 17$)	p value
Mean age (range), years	58 (29–85)	53.4 (13–74)	0.371
Sex			0.77
Male	27 (62.8%)	10 (59%)	
Female	16 (37.2%)	7 (41%)	
Clinical tumor stage (cT)			0.5
T1	12 (27.9%)	6 (35.3%)	
T2	12 (27.9%)	6 (35.3%)	
T3	1 (2.3%)	1(5.9%)	
T4	18 (41.9%)	4 (23.5%)	
Clinical nodal stage (cN)			0.54
N0	31 (72.1%)	15 (88.2%)	
N1	2 (4.7%)	1 (5.9%)	
N2a	3 (7%)	0	
N2b	4 (9.3%)	0	
N2c	23 (6.9%)	1 (5.9%)	
Mean BMI (range)	24.3 (18–40)	24.9 (17–35)	0.76
Laterality			0.11
Unilateral	28 (65.1%)	15 (88.2%)	
Bilateral	15 (34.9%)	2 (11.8%)	
Primary tumor management			0.54
None (other day)	5 (11.6%)	3 (17.5%)	
Without flap reconstruction	11 (25.6%)	8 (47.1%)	
With flap reconstruction	27 (62.8%)	6 (35.3%)	
ICU	34 (79.1%)	8 (47.1%)	0.015
Blood transfusion	8 (18.6%)	4 (23.5%)	0.66
Local complication	21 (48.8%)	2 (11.8%)	0.008
Mean drain stay (range), days	8 (3–16)	5.5 (3–9)	0.006
Mean length of stay (range), days	14.3 (2–49)	8.8 (1–50)	0.042
Mean total surgical time (range), min	482 (90–870)	464 (159–969)	0.96
Mean console time (range), min*	–	57 (48–80)	NA

*Applicable only for robotic surgeries

All cases were diagnosed with squamous cell carcinoma (SCC). Fifteen cases (34.9%) underwent a bilateral neck dissection, resulting in a total of 58 SNDs by the conventional approach, of which 18 included levels I–IV, 12 included levels I–IIa–III (sparing level IIb), and 28 included levels I–III. The SND was in 38 patients (88%) preceded by therapeutic excision of the primary tumor and in 27 (62.8%) followed by a reconstructive procedure (25 free vascularized flaps and 2 regional flaps). All descriptive information, including clinical and pathological staging, is shown in Table 1.

Considering the perioperative and postoperative treatment outcomes, the mean total surgical time was 482 min (range 90–870), including primary tumor resection and reconstruction. Thirty-four patients (79.1%) were admitted to ICU for the first postoperative day and eight patients (18.6%) received a blood transfusion during hospital admission (all eight submitted to reconstructive procedures). Mean duration of drainage was 8 days (range 3–16). Twenty-one (48.8%) patients suffered from local postoperative complications in the neck, including two cervical hematomas and 16 infections. One systemic complication was encountered (pneumonia with refractory sepsis). Three patients (7.0%) underwent a re-intervention during the postoperative period. The mean total length of hospital stay was 14.3 days (range 2–49).

These outcome measures were compared after stratification for need of any type of regional or distant reconstructive flap procedure. Those with reconstructive procedures had statistically significant worse results for all primary outcome indicators, except reoperation (Table 2). This is further illustrated in Tables 3 and 4, demonstrating perioperative and postoperative treatment outcome numbers and percentages after the conventional SND with a conventional approach in the patients without (Table 3) and with (Table 4) reconstruction.

Table 2 Comparison of outcome indicators between surgeries with or without flap reconstruction

	Without reconstruction ($N = 27$)	With reconstruction ($N = 33$)	p value
Local complications	4 (14.8%)	20 (60.6%)	<0.001
Reoperation	2 (7.4%)	3 (9.1%)	1.0
Surgical site infection	1 (3.7%)	17 (51,5%)	<0.001
Blood transfusion	0	12 (36.4%)	<0.001
ICU	11 (40.7%)	31 (93.9%)	<0.001
Drain time (>6 days)	11 (40.7%)	25 (75.8%)	0.006
Length of stay (>5 days)	9 (33.3%)	31 (93.9%)	<0.001
Surgery time (>4 h)	6 (22.2%)	33 (100%)	<0.001

Table 3 Comparison of outcome indicators including surgeries without flap reconstruction between conventional and retroauricular groups

	Conventional ($N = 16$)	Retroauricular ($N = 11$)	p value
Local complications	2 (12.5%)	2 (18.2%)	1.0
Reoperation	1 (6.2%))	1 (9.1%)	1.0
Surgical site infection	0	1 (9.1%)	0.4
Blood transfusion	0	0	NA
ICU	8 (50%)	3 (27.3%)	0.42
Drain time (>6 days)	8 (50%)	3 (27.3%)	0.42
Length of stay (>5 days)	5 (31.2%)	4 (36.4%)	1.0
Surgery time (>4 h)	1 (6.2%)	5 (45.5%)	0.02

Table 4 Comparison of outcome indicators including surgeries with flap reconstruction between conventional and retroauricular groups

	Conventional ($N = 27$)	Retroauricular ($N = 6$)	p value
Local complications	19 (70.4%)	1 (16.7%)	0.02
Reoperation	2 (7.4%)	1 (16.7%)	0.4
Surgical site infection	17 (63%)	0	0.01
Blood transfusion	8 (29.6%)	4 (66.7%)	0.15
ICU	26 (96.3%)	5 (83.3%)	0.33
Drain time (>6 days)	22 (81.5%)	3 (50%)	0.13
Length of stay (>5 days)	26 (96.3%)	5 (83.3%)	0.33
Surgery time (>10 h)	23 (85.2%)	5 (83.3%)	1.0

The mean number of retrieved lymph nodes for the 58 SNDs was 27.7 nodes (6–57). In the group of 28 conventional I–III SNDs, the number of retrieved nodes varied from 12 to 49 (median 29.5). In 12 dissections, the level IIb was spared (I–IIa–III SND), resulting in 6–34 resected lymph nodes (mean 19.3). In the 18 level I–IV SNDs, 10–57 nodes were removed (mean 33.2) (Table 5). The mean follow-up time was 17.3 months (range 1–27). One patient died within the first postoperative month due to a pneumonia and refractory sepsis. Regarding adjuvant treatment, 14 (32.5%) patients were submitted to radiotherapy and 11 (25.6%) to chemoradiation. Ten (23.2%) patients presented with recurrent disease during follow-up, of which two (4.7%) had a recurrence in the dissected neck, leading to a DFS of 76.8%.

Retroauricular approach

In the retroauricular group, there were 17 patients of which 7 (41%) were female. Eleven patients underwent endoscopic-assisted and six underwent robotic-assisted SND. The mean age was 53.4 years (range 13–74 years) and mean BMI was 24.9 kg/m^2 (range 17–35). One patient was diagnosed with a mucoepidermoid carcinoma of the tongue; all others with an SCC. Due to a bilateral SND in 2 patients, this group contains 12 endoscopy-assisted SND I–III in 11 patients and 7 robotic SND (6 SND I–III; 1 SND I–IV) in 6 patients. In 4 of the 18 SND I–III, the level IIb was spared. In 14 patients (82.4%), resection of primary tumor was performed simultaneously with the retroauricular SND. In 6 of these patients, there was a need for

Table 5 Comparison of number of retrieved lymph nodes between conventional and retroauricular groups

Levels resected	Conventional		Retroauricular		*p* value
	Number of dissections	Retrieved lymph nodes (median)	Number of dissections	Retrieved lymph nodes (median)	
I–II–III	28	29.5	14	28	0.769
I–IIa–III	12	19	4	14.5	0.247
I–II–III–IV	18	33.5	1	23	0.272

reconstruction with a free vascularized flap, which could be performed without additional skin incisions. Seven patients were submitted to tracheostomy.

For this group, the total surgical time varied considerably especially due to primary tumor resection and reconstruction via minimal access (range 159–969 min). When focusing only on the SND, the estimated operating time for flap raising, retractor placement, and conventional dissection under direct visualization lateral to the carotid artery ranged from 30 to 75 min. Additional 30–105 min were needed for completing the endoscopy-assisted dissection medial to the carotid artery. Docking of the da Vinci Si system usually was done in about 5–10 min. The mean console time for the robotic procedures was 57 min (range 48–80). No intra-operative complication or unintentional injury was recorded and 4 patients (23.5%) (all submitted to reconstructive procedures) needed blood transfusion during admission. Drains were removed after a mean time of 5.5 days (range 3–9). Two local postoperative complications (11.8%) were encountered. One patient presented with a cervical hemorrhage during extubation following an endoscopic SND I–III, which was resolved by re-exploration using the same approach and ligation of a muscular vessel in level IIB. The other case concerned a surgical site infection of the neck treated with needle aspiration and antibiotics without further complications. We also observed two of our early cases presenting with permanent marginal branch paresis (11.8%), and other five (29.6%) with transient paresis. Three patients (17.6%) suffered from systemic complications (pneumonia) and one had surgical infection in oral cavity, probably related to the primary tumor resection and reconstruction (three of them received free-flap). One patient (5.9%) underwent reoperation because of partial flap loss (skin island). The mean total length of hospital stay was 8.8 days (range 1–50). Excluding patients that received free-flap reconstruction, we had a mean length of stay of 5 days and considering only the three patients that were not submitted to primary tumor resection at the same time, the length of stay was 2 days or less. These outcome measures, again stratified for need of reconstruction, are shown in Tables 3 and 4.

Considering the oncological outcome, the mean number of retrieved LNs was 23 (range 12–52). Excluding the SND I–III that preserved level IIb and the SND I–IV, we had 14 SND I–III with a mean number of 28 (range 13–52) retrieved LNs (Table 5). This group had a mean total follow-up time of 18.6 months (range 10–27). Eight (47%) patients received adjuvant treatment, of which 6 (35.23%) received radiotherapy and 2 (11.8%) chemoradiation. During follow-up, four (23.5%) recurrences were diagnosed leading to a DFS of 76.5%. Two (11.8%) patients had recurrence in a dissected neck.

Comparison of the conventional and retroauricular approach

Comparison of both groups focused on the primary endpoint using peri and postoperative outcome indicators is shown in Tables 1, 3, and 4. In the procedures without reconstruction, surgical time was significantly longer for the retroauricular approach. However, for cases that received major reconstruction, the incidence of local complications and surgical site infection was significantly higher in the conventional group. Although we are aware of a significant rate of marginal branch paresis following the conventional neck dissection in our center, we were not able to precisely assess that in this retrospective study and compare it with the rate found in retroauricular group.

Although the follow-up time was short, oncologic outcome was compared for the two groups using the number of retrieved lymph nodes and disease-free survival (DFS). Stratifying neck dissections by levels resected, we did not find any significant difference in the number of retrieved lymph nodes described in the pathology reports (Table 5; Figs. 4, 5). In addition, there was no significant difference in DFS when comparing the conventional and retroauricular approach, even after stratification for TNM stage (Figs. 6, 7, 8).

Discussion

This aim of this study was to assess the feasibility of the endoscopic and robotic-assisted selective neck dissection via a retroauricular approach. Currently, there is no FDA

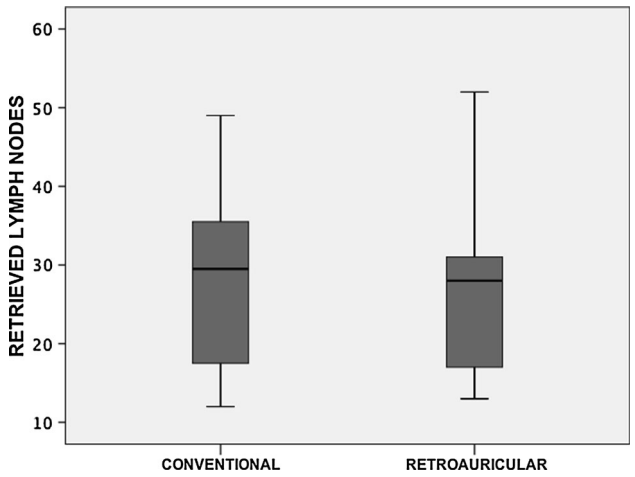

Fig. 4 Boxplot diagram comparing number of LN retrieved in retroauricular vs conventional SND I–II–III

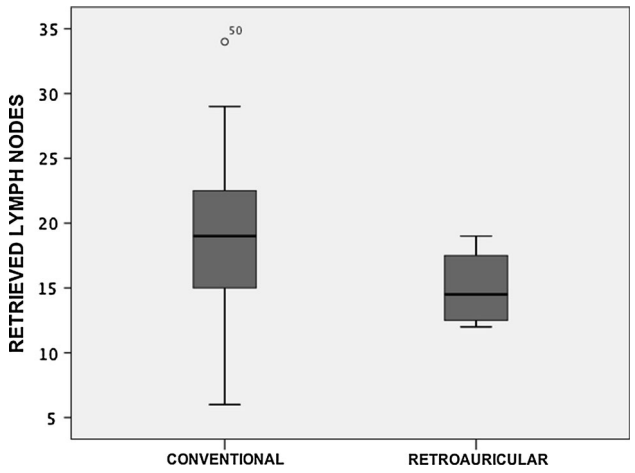

Fig. 5 Boxplot diagram comparing number of LN retrieved in retroauricular vs conventional SND I–IIa–III

approval for this indication, making the use of this technique off-label. It is only applied in a few departments around the world and evidence in English literature is limited and originates predominantly from a single department describing experiences in the Asian population. Smaller contributions come from Europe [18] and Northern America [16]. Interestingly, population demographics can be a limiting factor in the applicability of these new techniques due to anatomical restrictions. Therefore, by reporting on the first single institute cohort from Latin America, this study adds valuable information on minimal invasive and remote access surgery of the neck in oral cavity cancer. By including patients with different clinical stages of neck disease (N0–2) and patients undergoing reconstructive procedures through the same remote access approach, the results truly reflect daily clinical practice and make this a unique and innovative study. However, as most retrospective studies, also this report has some methodological limitations such as inclusion bias and the lack of a case-matched control group. Although the study sample is small, it reflects our initial experience, and with our increasing experience with retroauricular endoscopic and robotic neck dissection, we will have larger series with longer follow-up in a near future.

The advent of minimally invasive surgical techniques began as early as the 1980s, soon followed by the introduction of surgical robotics in 1985 [26]. It is characterized by a magnified, illuminated, and adequate operative view and allows the surgeon to identify anatomy more easily and perform an accurate surgical dissection and complete tumor resection. In 1997, Gagner described a subtotal parathyroidectomy as the first totally endoscopic-assisted procedure in head and neck surgery [27]. Many studies followed on video-assisted and endoscopic procedures in this field. However, recent research focus has been shifting more towards implementation of the da Vinci surgical robot, as this technique addresses some drawbacks of endoscopic surgery. These limitations of endoscopic surgery include a reduced range of motion [11, 14, 21, 23, 28, 29] with various collisions between operator and assistant [14, 21, 29], a two-dimensional view with lack of depth perception [11, 14, 21, 28, 29], impaired eye-hand coordination [11, 21, 29], minimal tactile sensation [11, 28], and a steep learning curve [11, 14, 29]. Use of a robotic surgical system offers the advance of a stable three-dimensional binocular magnification [3, 11, 14, 21, 28], motion scaling [11, 28], tremor filtration [3, 11, 21, 28], 7 degrees freedom with wristed articulated movements [3, 11, 14, 21, 28], a shortened learning curve [11, 14, 28], superior surgeon ergonomics [11, 21, 28], and improved instrumental dexterity [11, 21, 28]. This does not mean that there is no more role for endoscopic surgery since the introduction of the da Vinci robot. Although the latter has some clear advantages, comparative studies for endoscopic and robotic-assisted techniques have not been able to illustrate differences in outcome by simple comparison of numbers such as blood loss, conversion rate, or recovery time [11, 21]. In addition, obstacles for popularization of robot-assisted surgery may be the costs of the device and training. In this case, endoscopic surgery has an advantage in terms of cost-effectiveness [30]. Therefore, as mentioned earlier, endoscopic surgery could well be suggested as alternative treatment option to patients who cannot afford costly robotic surgery or in hospitals that do not posses the infrastructure or economic means for placement of a surgical robot [14, 29].

Cervical nodal metastasis is considered one of the most important prognostic factors in head and neck cancer [31]. As there is no consensus on the proper management of the clinically negative neck, establishing an optimal treatment remains challenging [32]. Especially because of its

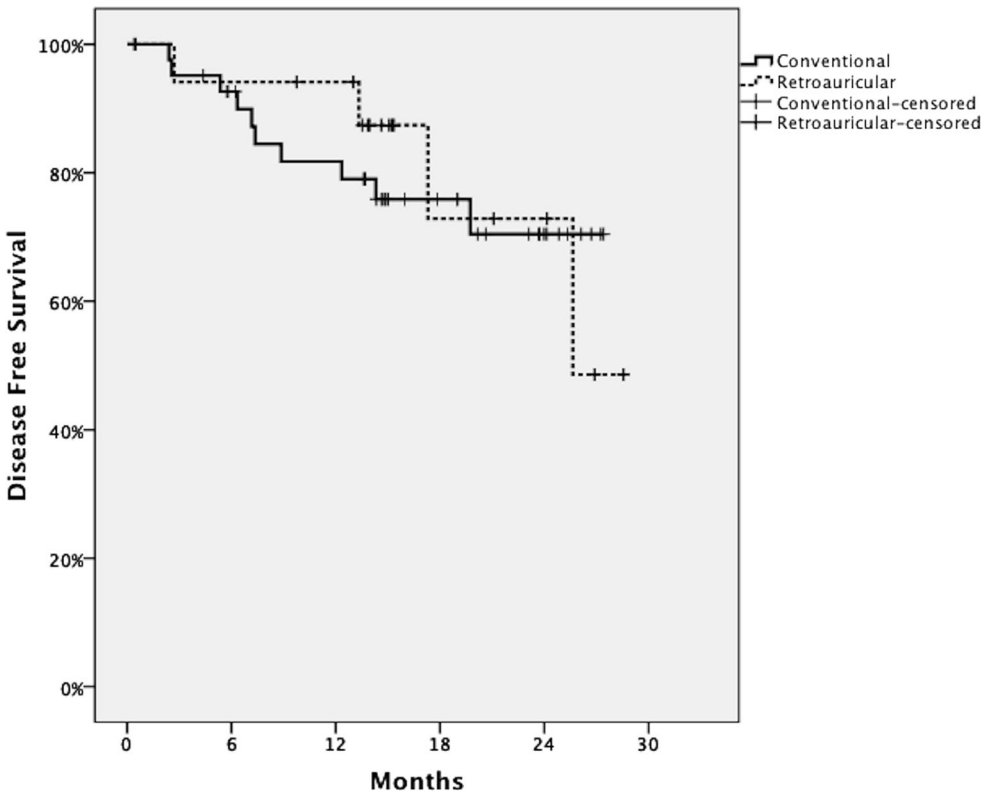

Fig. 6 Kaplan–Meier survival analysis. All cases included

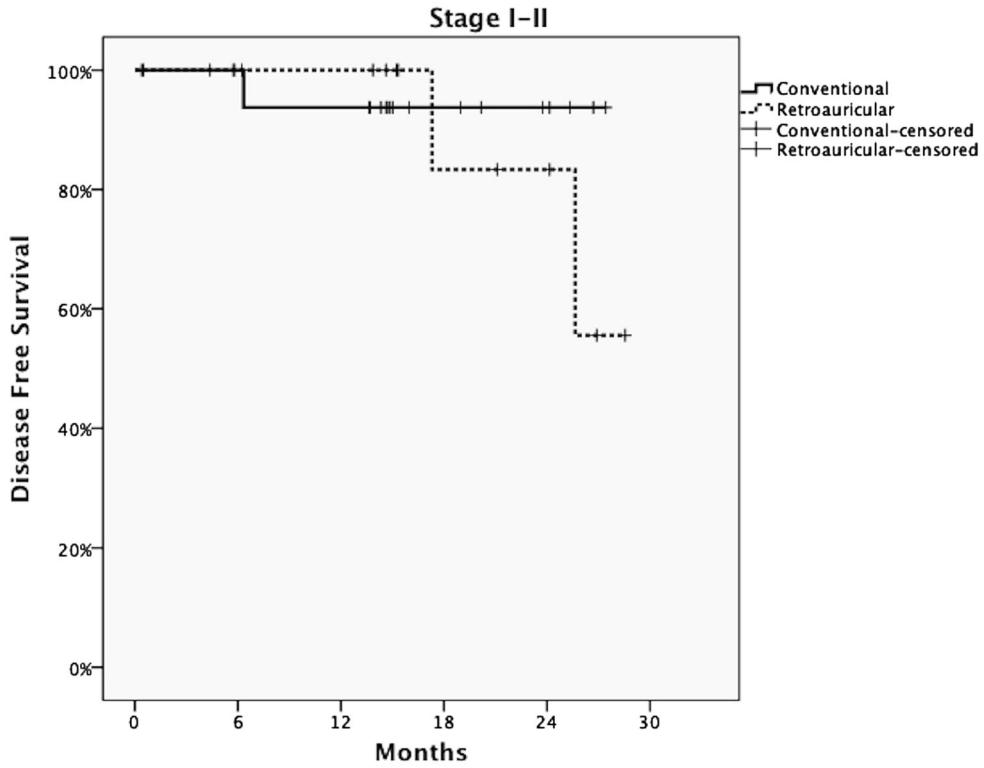

Fig. 7 Kaplan–Meier survival analysis. Stages I–II

associated morbidity, the role and extent of elective neck dissection is widely debated [33–35]. Besides the potential morbidity such as shoulder dysfunction, pain, lymphedema, contour changes, and lower lip paresis [36, 37], the conventional neck dissection always includes a long incision in the neck, leading to unsightly neck scars

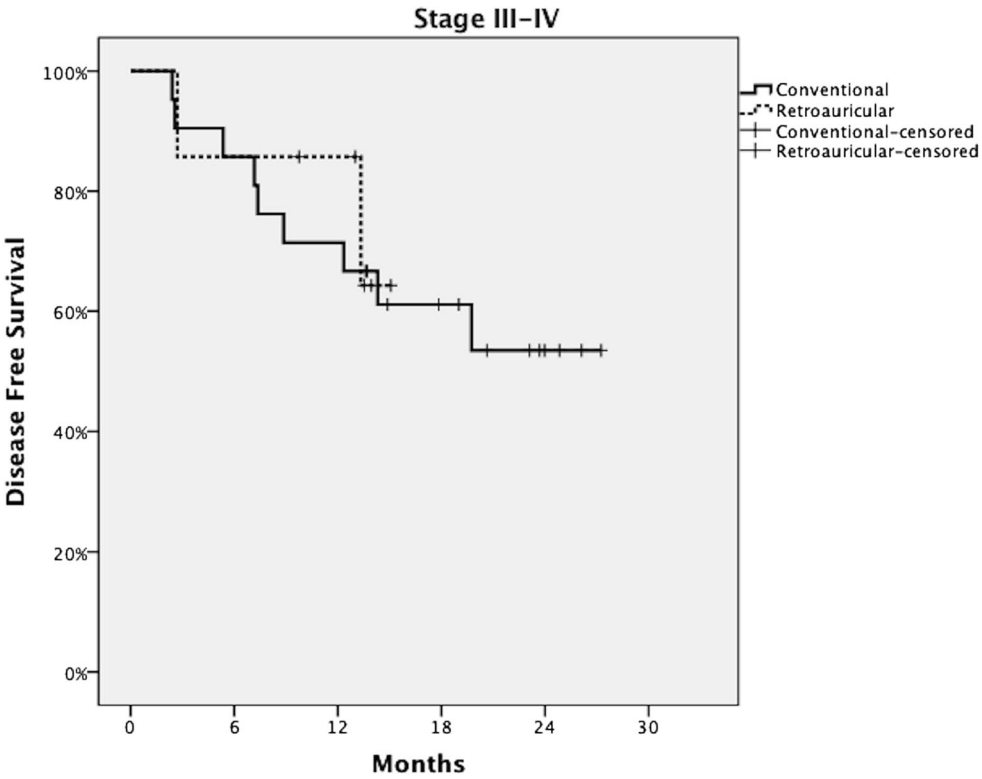

Fig. 8 Kaplan–Meier survival analysis. Stages III–IV

that cannot be hidden. This is especially problematic in the era of increasing HPV-related tumors in young individuals and the Asian and African population that have a greater propensity to form keloids and hypertrophic scars [38]. With the advent of minimal invasive techniques that offer the ability for mini-incision open, video-assisted, and complete endoscopic procedures, the likelihood of unsatisfactory cosmetic results of the neck is reduced [39]. Initially, the incisions were minimized leading to superior cosmetic results and similar completeness of resection [11, 27, 40, 41]. These minimal incisions have also been described for neck dissection in oral squamous cell carcinoma [22]. Ideally, complete avoidance of neck incisions should be pursued by the use of extracervical remote access approaches [11]. The initially introduced transaxillary approach was successful in lateral neck dissection, but yielded difficulties in exposure and dissection of the upper neck levels that are especially important in treatment of oral cancer [42]. After modifications [43] and preclinical studies [15], a retroauricular approach was suggested. This access has the advantages of being done in an anatomical area that is familiar to head and neck surgeons and overcomes some important drawbacks of the transaxillary approach, such as limitation of the surgical invasiveness by shortening the dissection distance to the target area [44], easier dissection in the superior to inferior direction with independence of the clavicle prominence, and no increased risk of brachial plexus injury [10, 45]. Its concept was originally described for parotidectomy [25, 46] and first reported for robotic thyroidectomy [47]. Subsequently, the group of Lee et al. published a series of patients who successfully underwent a robot-assisted SND of levels I–III and later other series of patients undergoing a robot-assisted SND of levels II–V and removal of benign upper cervical masses through a retroauricular and modified facelift approach [10, 12, 13, 21, 25]. Park et al. noticed that the retroauricular approach provided sufficient working space for the robotic arm without the preauricular incision, making it less invasive and enabling a completely hidden scar [10].

When comparing the robotic and endoscopic-assisted retroauricular approach with the conventional neck dissection, the results of the current study coincide with the results in literature [10, 13, 14, 16, 18, 19]. In our sample, there was no significant different perioperative or postoperative complication (e.g., hematoma, seroma, or surgical site infection) related to the approach or surgical technique. In the retroauricular group, there was no conversion to open surgery; no prolonged hospital stay and the important neurovascular structures were preserved in all cases. The incidence of low-grade marginal nerve paresis was considered acceptable when compared to the conventional procedures, as well when compared to the previous published studies [13, 14, 21]. Unfortunately, oncologic effectiveness could not be confirmed due to the small study population and short follow-up, but the number of retrieved

lymph nodes as alternative measure was comparable between both groups and similar to the previous publications on classic or retroauricular SND [13, 14, 48, 49]. Although not individually evaluated as outcome variable, the retroauricular approach offered all the advantages already described such as excellent cosmesis with a hidden scar in the postauricular hairline (Fig. 9) [10, 13, 14], no risk of exposed vessels in case of complicated wound healing [10], and benefits in functional aspects such as drainage of lymphedema [10, 14]. Another potential advantage is the more precise and fine dissection granted by da Vinci system during robotic surgery, when compared to the conventional surgery. In our experience, superior cosmetic outcome is the major advantage, followed by reduced edema in neck and face, although we do not have objective analysis on this yet.

Potential disadvantages mentioned by opponents of the retroauricular approach, such as auricular nerve paresthesia [22], auricular deformity [22], and cervical postrhytidectomy contracture [22], were not encountered in the current studied cohort. Proper visualization and dissection of the marginal branch is feasible without any major technical challenge using retroauricular approach. However, skin traction and thermal injury should be considered as potential hazards to this nerve during robotic or endoscopic dissection. The overriding disadvantage of the retroauricular approach remains the prolonged operative time, mainly due to the time-consuming subplatysma flap elevation and working space creation [10, 13, 14, 16, 19]. Although confirmed again in this study, a clear reduction in surgical time from the first to the last case was witnessed. As with any new technology, there is a learning curve and a period of adaptation to overcome. In addition, according to the experience in this cohort, most neck levels (especially level II and III) can be performed under direct visualization from the retroauricular approach. If robotic and endoscopic assistance is only used for completion of dissection in the most difficult accessible areas, operative time might be further decreased.

Fig. 9 Neck appearance following the conventional (**a**, **b**) and retroauricular (**c**, **d**) neck dissection

While the procedure of endoscopic and robotic-assisted SND via a retroauricular approach is still under development, it is important to explore potential refinements of the current procedure and exploit the opportunities created by further technological development. This would include development of smaller instruments and more flexible tools that could facilitate the procedure. But also, incorporation of image guided navigation techniques would be a great advantage to verify the surgical position and provide feedback if adequate tumor resection margins are obtained. With the assistance of Tilepro™ multi-input display software, the Medtronic (Minneapolis, MN, USA) navigational unit can already be interfaced with the da Vinci Si [28]. Another interesting next step could be the use of real-time imaging with intra-operative use of MRI, enabling excellent continuous visualization of soft tissues in areas with limited access [3, 50]. However, this technique is still tremendously time-consuming, associated with high costs and would require further development of non-magnetic surgical tools. In addition, important advances might be achieved in the field of functional rehabilitation, where microvascular transplantation of free grafts has become increasingly important. This is the first comparative study which shows that this approach can also facilitate direct anastomosis. Future advancements can further ameliorate this development, for example by investigating the role of robotic-assisted anastomosis combined with this approach.

Use of minimal invasive techniques for other indications, such as thyroidectomy, has already proven that adequate patient selection and determination of relative contra-indications such as specific tumor characteristics have an important impact on successful outcome [51]. Therefore, large prospective studies need to be designed and executed evaluating clinical and functional outcomes, including long-term recurrence rates, costs, and various quality of life variables, in well-defined cohorts. Once the real value, indications and oncologic safety of this technology have thoroughly been assessed and validated,

naturally increased use of this technique is foreseen, as was the case for TORS after FDA approval [24]. Thereby it is very important to keep in mind that for these highly complex and low frequent procedures, better outcomes are expected in high volume centers and surgeons must first have considerable experience with the conventional open techniques before turning to these highly technological complex procedures.

Conclusion

This retrospective study on the initial experience with the retroauricular approach for endoscopic and robotic SND has shown that this approach is feasible, safe, and oncologically efficient when compared to the conventional surgery. It can be used for selected cases with a clear cosmetic benefit. Also departments without access to the technology of the da Vinci surgical robot can obtain similar cosmetic results using the endoscopic procedure. Obviously, further prospective analysis in a larger number of cases is necessary to clarify the advantages, establish a better case selection, and furthermore evaluate costs, functional outcome, patient satisfaction, and learning curve.

Compliance with ethical standards

Conflict of interest Author Renan Bezerra Lira, Author Thiago Celestino Chulam, Author Genival Barbosa de Carvalho, Author Willem Hans Schreuder, Author Yoon Woo Koh, Author Eun Chang Choi, and Author Luiz Paulo Kowalski declare that they have no conflict of interest.

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