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Resection of benign tumours of the submandibular gland with harmonic scalpel-assisted minimally extracapsular dissection

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Abstract

Objective: This study was performed to compare the oncologic and functional outcomes in patients with benign submandibular gland (SMG) tumours after harmonic scalpel-assisted minimally extracapsular dissection (HS-MECD) or total gland excision (TGE).

Methods: In total, 133 consecutive patients who were preoperatively diagnosed with benign SMG tumours (pleomorphic adenoma, Warthin's tumour, basal cell adenoma, or lymphoepithelial cyst) from 2013 to 2016 were included in this two-centre retrospective study. Sixty-four patients underwent HS-MECD and 69 patients underwent TGE. All tumours were within 4 cm. Surgical variables, complications, functional outcomes, and recurrence rates were evaluated.

Results: The operation time, blood loss, drainage time and volume, and length of hospital stay were significantly lower in the HS-MECD than TGE group. HS-MECD reduced local pain and transient facial nerve paralysis outcomes. Incision scars and facial deformities were less visible according to the visual analogue scale. No significant differences were found in either unstimulated or stimulated whole saliva at 1 month postoperatively, whilst higher unstimulated levels were detected in the HS-MECD group at 6 months. The recurrence rate was similar between the two groups.

Conclusion: For benign SMG tumours of <4 cm, HS-MECD represents a less invasive technique than TGE and affords patients increased postoperative functionality.

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Introduction

The submandibular gland (SMG) is the second largest salivary gland and is responsible for 60% to 65% of resting saliva production.[1,2] The SMG is involved in up to 10% of salivary gland tumours, and only half of these lesions are benign.[3] Among these benign tumours, pleomorphic adenoma is the most common histological type.[4,5] Because of the simplification of surgical procedures and the rarity of local recurrence, total gland excision (TGE) is considered the gold standard for the surgical treatment of benign SMG tumours.[6,7] However, this approach leads to loss of function of the affected SMG and further complications after surgery, including neurological damage, visible scarring, and symptomatic xerostomia with impairments of patients' life quality.[8,9] These features have prompted surgeons to discuss the possibility of minimising the extent of the operation through methods that maintain the benefits of TGE, but with fewer drawbacks.

Extracapsular dissection for benign tumours of the parotid gland has been extensively studied,[10,11] but SMG approaches have been less thoroughly investigated.[12,13] Minimally extracapsular dissection (MECD), which is approximately equivalent to meticulous nodulectomy, further reduces the size of the surgical defect and potential complications.[14] With the development of surgical instruments, the harmonic scalpel (Harmonic System; Ethicon Endo-Surgery, LLC, Guaynabo, Puerto Rico, USA) has been used in various head and neck surgeries. Use of this device can lead to reduced lateral thermal spread and adjacent tissue destruction,[15,16] contributing to reduced postoperative pain and less bleeding in the surgical area.[17]

This study was performed to compare the oncologic outcomes, surgical variables, complications, and functional results of TGE and harmonic scalpel-assisted MECD (HS-MECD), which is an advanced technique in the management of benign tumours of the SMG. Hypothetically, because HS-MECD is less invasive, this new approach may lead to fewer complications and improved outcomes without increasing the incidence of recurrence.

Patients and methods

Patient inclusion

This retrospective study was performed as preliminary research for a multicentre randomised clinical trial to identify the most preferable surgical technique for patients diagnosed with benign tumours in the SMG. Therefore, computer-generated random numbers from SPSS Statistics version 18.0 (SPSS Inc., Chicago, IL, USA) were applied to determine the different surgical procedures that would be performed before enrolment in the randomised clinical trial. Patients with full medical archives from two medical centres from 2013 to 2016 were included in the present retrospective analysis. The two hospitals were the First Affiliated Hospital of Huzhou University and the Second People's Hospital of Changshu. The patients were divided into a TGE group and HE-MECD group. The PASS 11.0 software

program (NCSS, LLC, Kaysville, UT, USA) was used for sample size calculation according to the primary parameter of the study. Preoperatively, all patients were evaluated by clinical examination and ultrasonography as well as contrast-enhanced tomography or magnetic resonance imaging of the bilateral SMG. All lesions were diagnosed by fine needle aspiration cytology (FNAC) under ultrasound guidance to confirm their benign nature. The results of FNAC were confirmed by frozen section and permanent histopathologic diagnosis postoperatively. The largest transverse diameter of the tumours according to the histopathologic diagnosis was considered the tumour size. All patients were informed of the surgical details and possible complications of TGE and HS-MECD preoperatively. We excluded patients with preoperative suspected malignancy, a history of SMG surgery, bilateral SMG tumours, and a tumour size larger than 4 cm. We also excluded patients with insufficient data, those who were lost to follow-up, and those with systemic diseases that could affect the outcome of the operation (e.g., Sjogren's syndrome, anaemia, or corticosteroid therapy). The institutional review boards of both medical centres approved this retrospective study, and the requirement for written informed consent of the included patients was waived.

Surgical and follow-up data collection

Intraoperatively, the operation time (recorded as the interval from skin incision to closure) and the volume of blood loss was monitored by an independent observer of the operation from the time of skin incision with a scalpel until spontaneous tissue bleeding stopped. For these measurements, accurate volumetric indices were obtained using a YX980D High Vacuum Medical Electric Operating Suction Apparatus Machine (WANROOEMED, Jiangsu, China). The total drainage times and drainage volumes were measured postoperatively. The length of hospital stay (LOS) and surgical complications were assessed. In addition, the patients' subjective satisfaction with the cosmetic outcomes (including incision scarring and sunken facial deformity) was evaluated 6 months postoperatively using a visual analogue scale (VAS) ranging from 0 to 10, with higher scores indicating improved patient satisfaction. The facial nerve function was clinically assessed using the House–Brackmann grading system,[18] and permanent facial paralysis was defined as facial paralysis lasting $\geq$1 year. Data concerning salivary gland function were obtained before and after the operation. All patients included in the study were followed up *via* regular outpatient appointments. The follow-up period was calculated from the date of the first treatment to the date of the last available assessment. Cases of recurrence in the two groups were also calculated.

Surgical techniques

Under general anaesthesia, the patients were placed in the supine position with the neck extended and the chin rotated to the opposite side. TGE began with a transcervical incision below the mandibular border. The skin flap was elevated under the platysma, and the SMG and tumour were exposed. The facial artery and vein were ligated before the gland was mobilised anteriorly from the free edge of the mylohyoid muscle. Wharton's duct was also ligated while taking care to avoid injury to the lingual and hypoglossal nerves. Finally, the tumour was removed with the whole SMG.

Advanced surgical instruments were applied for performance of HS-MECD, which represents a highly functional technique. A smaller submandibular incision was made according to the tumour position and size. The skin flap was elevated to

expose the SMG, and the marginal branch of the facial nerve was identified and preserved. If the tumour was located in the superficial or tail part of the SMG, the edge of the tumour was marked and carefully mobilised with the harmonic scalpel outside of the capsule. Particular attention was paid to ensure that no vital structures (such as facial nerve branches or facial vessels) remained within the cut tissue. If the tumour was located in the deep portion of the SMG, the gland was mobilised with the harmonic scalpel to separate it from the free edge of the mylohyoid muscle and lifted to allow exposure of the deep portion of the SMG with the lesion. Wharton's duct, the lingual nerve, and the hypoglossal nerve were identified. Once the tumour was located, harmonic scalpels were used for dissection around the tumour capsule. Because the facial artery passed upward and forward to enter the deep surface of the SMG, it was carefully preserved along with the duct and nerve tissue. Following tumour resection, the residual SMG was sutured back to its previous position with the surrounding tissue. During the procedure, the active vibrating terminal of the harmonic scalpel remained in contact with the tumour capsule, which was never opened to avoid incidental damage to vital tissues (Figure 1a–d).

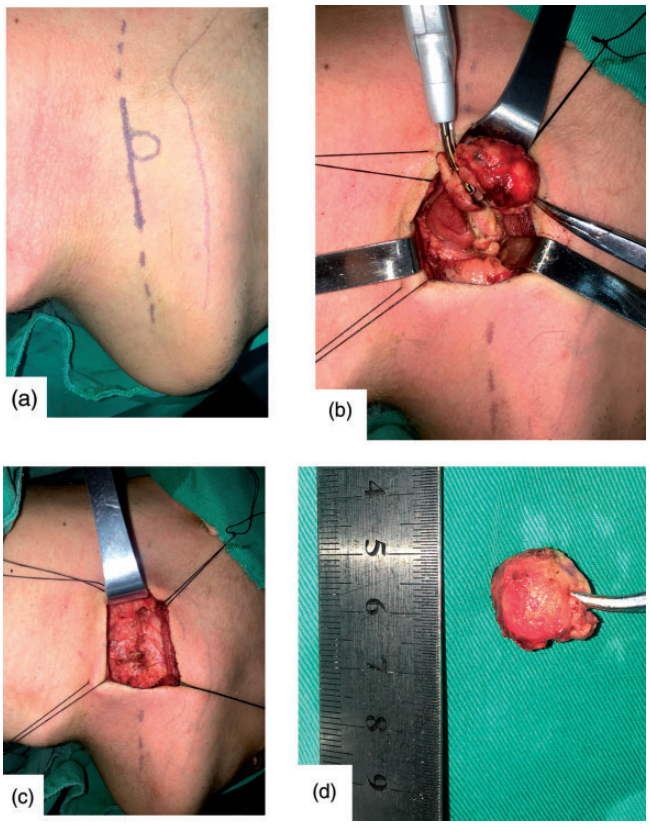

Figure 1. Surgical procedure of harmonic scalpel-assisted minimally extracapsular dissection. (a) Surgical mark on the skin. (b) Extracapsular dissection with harmonic scalpel. (c) Anatomical replacement of surrounding tissue. (d) The removed tumour.

Immediate frozen section pathology was performed after removal of the specimen for each included patient. This protocol is suitable, cost-beneficial, and required to confirm the nature of the tumour and verify the operative margins. All included patients underwent mini-vacuum drainage (Medinorm HVS-200 Complete Kit CH8 with valve; MEDINORM Medizintechnik Gmbh, Spiesen-Elversberg, Germany) performed postoperatively in the surgical bed, and the drain was removed within 2 days. Monopolar and bipolar electrocautery were performed in the TGE group. A harmonic scalpel was used only in the HS-MECD group. Two experienced surgeons performed all of the operations in this study.

Whole saliva collection

To compare the impact of the operation on salivary gland function, the rate of unstimulated whole saliva (UWS) and stimulated whole saliva (SWS) in all included patients was evaluated preoperatively and at 1 and 6 months postoperatively. The specific technique for calculation of the saliva flow rates (mL/minute) was performed by the same experienced clinician following the technique described by Jacob et al.[19] Patients were instructed to rinse their mouth with water prior to saliva collection. Unstimulated saliva was collected using the spitting method and placed into preweighed test tubes for 10 minutes. The procedure for collection of the stimulated saliva was identical except for stimulation with acidic material (a 200-mg ascorbic acid tablet was placed on the dorsal tongue). After collection, the samples were weighed on an electronic balance and the salivary flow rate was calculated.

Statistical analysis

Categorical data are presented as frequency (n) and percentage (%), whereas continuous data are presented as mean ± standard deviation. For continuous data, the mean and standard deviation were sometimes replaced with the median and interquartile range when the data were not normally distributed. Pearson's chi-square (χ^2) test, P-value correction, or Fisher's exact test was used for categorical data; Student's t-test was used for data with a normal continuous distribution; and the Mann–Whitney U test was performed for data with a non-normal continuous distribution. PASS 11.0 software (NCSS, LLC) was used for the sample size calculation. SPSS Statistics version 18.0 (SPSS, Inc.) was used for all data analyses, and P values of <0.05 were considered statistically significant.

Results

In total, 133 patients were included in this study. The demographic and tumour characteristics of the included patients are summarised in Table 1. Sixty-four patients (48.1%) underwent HS-MECD whilst 69 patients (51.9%) underwent TGE. The demographic data, tumour size, and mean follow-up period were comparable between the two groups. Four types of benign lesions were confirmed by postoperative histopathological examination: pleomorphic adenoma, Warthin's tumour, basal cell adenoma, and lymphoepithelial cyst. According to the tumour location, the SMG was divided into three parts: the tail portion (defined as the free end of the SMG), the superficial portion (defined as the tumour proximal to the platysma side), and the deep portion proximal to the mylohyoid muscle.

Details regarding the intraoperative and postoperative variables of the included patients are shown in Table 2. The operation time and blood loss were significantly lower in the HS-MECD than TGE group ($P < 0.001$). However, the operation times

Table 1. Characteristics of patients by type of operation.

		Type of operation			
	Total (n = 133)	TGE (n = 69)	HS-MECD (n = 64)	t/χ^2	P
Age at initial presentation, years	40.2 ± 11.3	41.2 ± 9.9	39.2 ± 12.7	1.003	0.318
Sex				0.164	0.685
Male	71 (53.4)	38 (55.1)	33 (51.6)		
Female	62 (46.6)	31 (44.9)	31 (48.4)		
Smoking				0.001	0.973
Yes	31 (23.3)	16 (23.2)	15 (23.4)		
No	102 (76.7)	53 (76.8)	49 (76.6)		
Tumour size, cm	2.60 ± 0.70	2.65 ± 0.74	2.54 ± 0.67	0.873	0.384
Tumour location				1.176	0.556
Tail	35 (26.3)	18 (26.1)	17 (26.6)		
Superficial part	86 (64.7)	43 (62.3)	43 (67.2)		
Deep part	12 (9.0)	8 (11.6)	4 (6.2)		
Pathology				0.684	0.877
Pleomorphic adenoma	110 (82.7)	57 (82.6)	53 (82.3)		
Warthin's tumour	17 (12.7)	8 (11.6)	9 (14.1)		
Basal cell adenoma	3 (2.3)	2 (2.9)	1 (1.8)		
Lymphoepithelial cyst	3 (2.3)	2 (2.9)	1 (1.8)		
Follow-up period, months	41.8 ± 10.1	41.3 ± 9.7	42.4 ± 10.5	0.636	0.526

TGE, total gland excision; HS-MECD, harmonic scalpel-assisted minimally extracapsular dissection.
Data are presented as mean ± standard deviation or n (%).
Analysis was performed using Student's t-test for continuous data and the chi-square (χ^2) test for categorical data.

Table 2. Intraoperative and postoperative variables in the two groups.

	Type of operation			
	TGE (n = 69)	HS-MECD (n = 64)	t/χ^2	P
Intraoperative				
Duration of operation, minutes				
Total	51.8 ± 6.4	37.7 ± 7.1	11.894	<0.001
Superficial or tail	51.8 ± 6.3	36.3 ± 5.0	14.9	<0.001
Deep	51.4 ± 8.0	58.0 ± 1.8	2.234	0.055
Surgical bleeding, mL	43.9 ± 3.7	20.8 ± 3.3	37.691	<0.001
Tumour spillage	1 (1.4)	3 (4.7)	0.342	0.559*
Postoperative				
Drain time, hours	38.9 ± 3.4	23.0 ± 4.4	23.166	<0.001
Drain volume, mL	34.8 ± 4.1	17.2 ± 5.5	20.741	<0.001

TGE, total gland excision; HS-MECD, harmonic scalpel-assisted minimally extracapsular dissection.
Data are presented as mean ± standard deviation or n (%).
Analysis was performed using Student's t-test for continuous data and the chi-square (χ^2) test for categorical data.
*Analysis was performed using p-value correction.

of patients with a tumour in the deep portion of the SMG were comparable. During the operation, tumour spillage occurred in three patients in the HS-MECD group and one patient in the TGE group; this difference was not statistically significant. All four patients were managed thorough irrigation and removal of tumour tissue. Postoperatively, significant differences were observed in the time and volume of wound drainage between the two surgical groups ($P < 0.001$).

Table 3 shows the surgical complications of patients in both groups. In the HS-MECD group, local pain was observed in 38 patients and decreased sensation occurred in 15 patients. These two variables were more frequently observed in patients of the TGE group ($P < 0.001$). No significant differences were observed in the development of haematomas, wound infection, or salivary fistulas between the two groups. The marginal branch of the facial nerve was unintentionally injured in 14 patients and permanently injured in 1 patient in the TGE group, whilst only 4 patients had transient facial nerve paralysis in the HS-MECD group (House–Brackmann grade II) ($P = 0.018$). Transient lingual nerve paralysis was observed in only two patients in the TGE group, and both patients had recovered by 3 months postoperatively.

The average LOS, VAS score, and recurrence rate of all included patients are shown in Table 4. The average LOS was significantly shorter in the HS-MECD than TGE group ($P < 0.001$). Moreover, the average VAS scores for patient satisfaction with the cosmetic outcome, specifically incision scarring and facial deformity, were significantly higher in the HS-MECD than TGE group ($P < 0.001$). Among all included patients, only one patient in the HS-MECD group developed recurrence without a significant difference between the groups.

The UWS and SWS data are summarised in Table 5. There was no significant difference in either UWS or SWS between the two groups before the operation. One month after the operation, the UWS was slightly higher in the HS-MECD than TGE group, but the difference was not

Table 3. Postoperative complications in the two groups.

	Type of operation			
	TGE (n = 69)	HS-MECD (n = 64)	χ^2	P
Local pain	61 (88.4)	38 (59.4)	14.706	<0.001
Decreased sensation	48 (69.6)	15 (23.4)	28.338	<0.001
Hematoma	6 (8.7)	2 (3.2)	0.97	0.325**
Wound infection	4 (5.8)	1 (1.6)	0.683	0.408**
Salivary fistula*	0 (0.0)	1 (1.6)	–	0.481
TFNP	14 (20.3)	4 (6.3)	5.593	0.018**
PFNP*	1 (1.4)	0 (0.0)	–	–
TLNP*	2 (2.8)	0 (0.0)	–	–

TGE, total gland excision; HS-MECD, harmonic scalpel-assisted minimally extracapsular dissection; TFNP, transient facial nerve paralysis; PFNP, permanent facial nerve paralysis; TLNP, transient lingual nerve paralysis.

Data are presented as mean ± standard deviation or n (%).

Analysis was performed using the chi-square (χ^2) test for the analysis of categorical data.

*The result had no statistical significance because of the lack of samples.

**Analysis was performed using p-value correction.

Table 4. Average LOS, VAS score, and recurrence rate in the two groups.

	Type of operation			
	TGE (n = 69)	HS-MECD (n = 64)	z/χ^2	P
Average LOS, days	4.0 ± 1.0	2.0 ± 1.0	9.128	<0.001
VAS score				
Incision scar	5.5 ± 1.0	8.5 ± 1.4	9.716	<0.001
Facial deformity	5.8 ± 1.4	9.0 ± 0.9	9.962	<0.001
Recurrence	0 (0.0)	1 (1.6)	–	0.481

HS-MECD, harmonic scalpel-assisted minimally extracapsular dissection; LOS, length of hospital stay; VAS, visual analogue scale, with higher scores indicating better patient satisfaction
Data are presented as median ± interquartile range or n (%).
Analysis was performed using the Mann–Whitney U-test; the χ^2 test was used for the analysis of categorical data.

Table 5. Whole saliva rates preoperatively and 6 months postoperatively.

	Type of operation			
Whole saliva rate (mL/minute)	TGE (n = 69)	HS-MECD (n = 64)	z	P
Preoperative				
UWS	0.74 ± 0.43	0.80 ± 0.41	1.011	0.312
SWS	1.70 ± 0.98	1.74 ± 0.80	1.868	0.864
1 month postoperatively				
UWS	0.43 ± 0.23	0.51 ± 0.21	1.599	0.110
SWS	1.62 ± 0.68	1.68 ± 0.66	0.982	0.326
6 months postoperatively				
UWS	0.43 ± 0.24	0.76 ± 0.33	8.162	<0.001
SWS	1.57 ± 0.86	1.70 ± 0.66	0.838	0.402

HS-MECD, harmonic scalpel-assisted minimally extracapsular dissection; UWS, unstimulated whole saliva; SWS, stimulated whole saliva.
Data are presented as the median ± interquartile range. Analysis performed using Mann–Whitney U-test.

significant. No significant differences were observed in the SWS between the two groups. The UWS was significantly higher in the HS-MECD group 6 months postoperatively ($P < 0.001$); at the same time, however, no significant difference was found in the SWS between the two groups. No patients complained of dry mouth, and no further complications or apparent reduction of saliva flow was observed in any of the patients during the follow-up period.

Discussion

Extirpation of the SMG along with the tumour is widely employed for benign tumours of the SMG; however, loss of the SMG may result in cosmetic and functional drawbacks.[20,21] Introduction of the harmonic scalpel was a major breakthrough in this field of surgery.[22] With the increased investigation of optimal outcomes of extracapsular dissection for benign parotid tumours, HS-MECD was developed as a

new surgical procedure for primary benign tumours of the SMG.

The harmonic scalpel has become an integral part of various surgeries because of its advantages including precise dissection, reliable haemostasis, relatively reduced tissue damage, and reduced operation times.[23,24] The scalpel acts by breaking hydrogen bonds to denature proteins and form a coagulum that seals vessels at a relatively lower temperature, thus decreasing thermal spread.[25] In 2018, Schneider et al.[17] compared patients' intraoperative and postoperative outcomes after use of either ultrasonic scalpel or monopolar electrocautery for skin incisions in neck dissection. The authors reported that the ultrasonic group experienced less pain and shorter cutting and bleeding times.[17] With the assistance provided by the harmonic scalpel, the operative time is shortened because no time is required to secure haemostasis or to ligate the pedicles; this makes the operative technique simpler, easier, and faster.[26] Lateral thermal damage of the harmonic scalpel is limited up to 2 mm beyond the tissue grasped within the forceps of the device. This allows safe vascular ligation with minimal risk of damage to the vital structures of the SMG that should remain preserved in HS-MECD, as demonstrated by the data in the present study. Because the temperature of activating the forceps using the harmonic scalpel can be varied according to different parameter settings, a short application time and suitable distance from the structures can be preserved, thus guaranteeing safe and efficient use.

In contrast to the parotid gland, which is divided into superficial and deep lobes by layers of the facial nerve, the SMG was artificially divided into three main portions in the present study. When the tumour was located in the superficial or tail part of the SMG, the procedure was straightforward and the tissue was palpable. HS-MECD was simple to perform, and the tumour size was not a limitation. However, if the tumour was located in the deep portion, the HS-MECD procedure was more difficult, and the vital structure neighbouring the portion was complicated to manage. Moreover, the limited operative field of HS-MECD could lead to inadvertent injury to the surrounding structures or tumour spillage. In the present study, longer surgical times were required in the HS-MECD than TGE group for tumours located in the deep portion of the SMG because of the need for complicated procedures including tumour exposure, tissue dissection, and preservation of structures around the tumour. Meanwhile, a greater level of tumour spillage occurred in the HS-MECD group, in which the tumour sizes were >3.5 cm. Thus, based on our experience, we do not recommend HS-MECD for tumours of ≥ 4 cm in the deep portion of the SMG. If the glandular tissue of the SMG has been compressed and reduced by tumour growth in the deep portion, there is no difference between resection of the whole gland or just the tumour when the lesion size is large.

A major concern of HS-MECD lies in the possibility of misdiagnosis following preoperative clinical and radiological examination. Therefore, as a low-risk and cost-effective procedure, FNAC was performed preoperatively in all patients in the present study. In previous studies, the overall sensitivity and specificity of FNAC were 78.0% and 97.7%, respectively.[27,28] The main purpose of FNAC in this study was to distinguish benign tumours from chronic sialadenitis and malignant tumours, both of which are inappropriate for HS-MECD because of the possibility of misdiagnosis.

The greatest concerns regarding limited surgery are the possibility of local recurrence and the risk of gradual development of malignant characteristics with repeated recurrences.[29] In the surgical specimens evaluated in previous studies, a significant

number of tumours in the SMG invaded the glandular parenchyma to a major extent and macroscopically reached the margins of the submandibulectomy specimens.[30] As such, the primary operation should extirpate the entire SMG to minimise the risk of recurrence. In contrast, the intactness and characteristics of the tumour capsule of the SMG reportedly have a protective function, even when surgical management leads to broad capsular exposure of the lesion.[31] Histological studies of pleomorphic adenoma of the SMG demonstrated that this tumour type was characterised by the consistent presence of an intact anatomical capsule, the infrequent occurrence of pseudopodia, a remarkably infrequent occurrence of secondary satellite tumour nodules, and a low proportion of the fragile risky myxoid subtype, which can be responsible for low recurrence rates. The present study showed excellent oncological outcomes; recurrence developed in only one patient in the HS-MECD group and none in the TGE group. The patient who developed recurrence was diagnosed with a 3.6-cm pleomorphic adenoma located in the deep portion of the SMG. The recurrence occurred 30 months postoperatively, and the tumour was treated by radical gland excision. The recurrence rate was comparable between the two groups during the follow-up period, corresponding to recurrence rates of 0.0% to 1.7% after submandibulectomy for submandibular pleomorphic adenomas.[32] Technically, the width of the vibrating forceps is approximately 2 mm, meaning that 2 mm of tissue around the tumour will be resected, including satellite nodules and pseudopodia. In other words, the real margin of the HS-MECD procedure is at least 2 mm around the tumour capsule, which can explain the low rate of recurrence observed in the patients.

HS-MECD requires only a limited incision that is dependent on the tumour size and location. The remaining volume of the SMG also prevents the sunken defect commonly encountered after TGE, resulting in symmetrical submandibular contours and an improved cosmetic outcome. The potential cosmetic benefits of HS-MECD were also provided in the current study, with both VAS scores higher in the HS-MECD group. Functional demands on the SMG are present for almost 24 hours per day, particularly during resting and sleeping periods, and have an important impact on oral cavity lubrification.[33] Xerostomia or dry mouth is one of the most disabling clinical symptoms related to salivary gland damage.[23] The postoperative salivary flow rates of patients in the current study were comparable with those in previous studies.[9] At 6 months postoperatively, the SWS was similar between the two groups whilst the UWS was significantly lower in the TGE group. This indicates improved function and quality of life after HS-MECD treatment, which can be explained by the SMG being responsible for the greater part of UWS and the residual gland of the affected side in patients who have undergone HS-MECD playing a role in salivary secretion. In addition, compensatory mechanisms in the remaining salivary glands of patients who have undergone TGE can occur in response to stimuli, resulting in an increased SWS and thus offsetting the differences between the two groups.

This study has certain limitations. The surgical costs of HS-MECD are higher than those of electrocautery. The outcomes obtained with this modified technique must also be considered because the majority of selected patients had substantially smaller, more mobile tumours, representing selection bias. Tumours that did not meet these criteria preoperatively or intraoperatively were removed with TGE techniques. Additionally, this was a two-centre

retrospective study with a limited number of patients, and the mean follow-up period was 41.8 months (shortest period, 27 months). Therefore, a larger sample of cases with longer-term follow-up will be necessary to draw more definitive conclusions. Moreover, the technique should be performed by highly experienced surgeons who are capable of dissecting vital structures around the tumour and SMG while avoiding capsular rupture or tumour spillage, which are potentially critical risk factors for complications. Although all of the included patients were treated by two experienced surgeons, the potential bias arising from the participation of different surgeons in this study cannot be ignored.

In conclusion, HS-MECD is a safe, effective, and definitive treatment for benign tumours of the SMG, yielding low morbidity and recurrence rates. This approach often results in fewer complications and improved patient outcomes for benign tumours smaller than 4 cm. Extensive surgical experience and effective decision-making are necessary to obtain successful outcomes of HS-MECD. Further validation in large-scale randomised controlled trials is warranted to determine the superiority of this modified technique.

Declaration of conflicting interest

The authors declare that there is no conflict of interest.

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References

1. Humphrey SP and Williamson RT. A review of saliva: normal composition, flow, and function. *J Prosthet Dent* 2001; 85: 162–169.
2. Diaz-Arnold AM and Marek CA. The impact of saliva on patient care: a literature review. *J Prosthet Dent* 2002; 88: 337–343.
3. Laskawi R, Ellies M, Arglebe C, et al. Surgical management of benign tumors of the submandibular gland: a follow-up study. *J Oral Maxillofac Surg* 1995; 53: 506–508.
4. Ito FA, Ito K, Vargas PA, et al. Salivary gland tumours in a Brazilian population: a retrospective study of 496 cases. *Int J Oral Maxillofac Surg* 2005; 34: 533–536.
5. Ethunandan M, Davies B, Pratt CA, et al. Primary epithelial submandibular salivary gland tumours-review of management in a district general hospital setting. *Oral Oncol* 2009; 45: 173–176.
6. Molina EJ, Mayer K, Khurana J, et al. Pleomorphic adenoma of the submandibular gland. *J Pediatr Surg* 2008; 43: 1224–1226.
7. Alves CA, Ribeiro Junior O, Borba AM, et al. Pleomorphic multicentric adenoma in the submandibular gland. *Head Neck Pathol* 2007; 1: 178–180.
8. Roh JL. Removal of the submandibular gland by a submental approach: a prospective, randomized, controlled study. *Oral Oncol* 2008; 44: 295–300.
9. Cunning DM, Lipke N and Wax MK. Significance of unilateral submandibular gland excision on salivary flow in noncancer patients. *Laryngoscope* 1998; 108: 812–815.
10. Xie S, Wang K, Xu H, et al. PRISMA-Extracapsular dissection versus superficial parotidectomy in treatment of benign parotid tumors, evidence from 3194 patients. *Medicine (Baltimore)* 2015; 94: e1237. http://doi:10.1097/MD.0000000000001237.
11. Mantsopoulos K, Koch M, Klintworth N, et al. Evolution and changing trends in surgery for benign parotid tumours. *Laryngoscope* 2015; 125: 122–127.
12. Ge N, Peng X, Zhang L, et al. Partial sialoadenectomy for the treatment of benign tumours in the submandibular gland. *Int J Oral Maxillofac Surg* 2016; 45: 750–755.

13. Min R, Zun Z, Siyi L, et al. Gland-preserving surgery can effectively preserve gland function without increased recurrence in treatment of benign submandibular gland tumour. *Br J Oral Maxillofac Surg* 2013; 51: 615–619.
14. Zheng CY, Cao R, Gao MH, et al. Comparison of surgical techniques for benign parotid tumours: a multicentre retrospective study. *Int J Oral Maxillofac Surg* 2019; 48: 187–192.
15. D'Ajello F, Cirocchi R, Docimo G, et al. Thyroidectomy with ultrasonic dissector: a multicentric experience. *G Chir* 2010; 31: 289–292.
16. Jackson LL, Gourin CG, Thomas DS, et al. Use of the Harmonic scalpel in superficial and total parotidectomy for benign and malignant disease. *Laryngoscope* 2005; 115: 1070–1073.
17. Schneider D, Goppold K, Kaemmerer PW, et al. Use of ultrasonic scalpel and monopolar electrocautery for skin incisions in neck dissection. a prospective randomized trial. *Oral Maxillofac Surg* 2018; 22: 169–175.
18. House JW and Brackmann DE. Facial nerve grading system. *Otolaryngol Head Neck Surg* 1985; 93: 146–147.
19. Jacob RF, Weber RS and King GE. Whole salivary flow rates following submandibular gland resection. *Head Neck* 1996; 18: 242–247.
20. Porter SR, Scully C and Hegarty AM. An update of the etiology and management of xerostomia. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2004; 97: 28–46.
21. Pow EH, McMillan AS, Leung WK, et al. Salivary gland function and xerostomia in southern Chinese following radiotherapy for nasopharyngeal carcinoma. *Clin Oral Investig* 2003; 7: 230–234.
22. Khan S, Khan S, Chawla T, et al. Harmonic scalpel versus electrocautery dissection in modified radical mastectomy: a randomized controlled trial. *Ann Surg Oncol* 2014; 21: 808–814.
23. Papavramidis TS, Sapalidis K, Michalopoulos N, et al. Ultracision harmonic scalpel versus clamp-and-tie total thyroidectomy: clinical trial. *Head Neck* 2010; 32: 723–727.
24. Docimo G, Ruggiero R, Gubitosi A, et al. Ultrasound scalpel in thyroidectomy. Prospective randomized study. *Ann Ital Chir* 2012; 83: 491–496.
25. McCarus SD. Physiologic mechanism of the ultrasonically activated scalpel. *J Am Assoc Gynecol Laparosc* 1996; 3: 601–608.
26. Talha A, Bessa S and Abdel Wahab M. Ligasure, Harmonic Scalpel versus conventional diathermy in excisional haemorrhoidectomy: a randomized controlled trial. *ANZ J Surg* 2017; 87: 252–256.
27. Stanek JJ and Khariwala SS. What is the utility of fine-needle aspiration in parotid gland neoplasms? *Laryngoscope* 2019; 129: 1255–1256.
28. Liu CC, Jethwa AR, Khariwala SS, et al. Sensitivity, specificity, and post-test probability of parotid fine-needle aspiration: a systematic review and meta-analysis. *Otolaryngol Head Neck Surg* 2016; 154: 9–23.
29. Becelli R, Morello R, Renzi G, et al. Recurrent pleomorphic adenoma of the parotid gland: role of neutron radiation therapy. *J Craniofac Surg* 2012; 23: e449–e450. http://doi:10.1097/SCS.0b013e318262d291.
30. Mantsopoulos K, Goncalves M, Schapher M, et al. Long-term oncologic and functional outcome in pleomorphic adenomas of the submandibular gland. *Laryngoscope Investig Otolaryngol* 2017; 2: 369–372.
31. Mantsopoulos K, Goncalves M, Koch M, et al. Submandibular gland pleomorphic adenoma: histopathological capsular characteristics and correlation with the surgical outcome. *Ann Diagn Pathol* 2018; 34: 166–169.
32. Rapidis AD, Stavrianos S, Lagogiannis G, et al. Tumors of the submandibular gland: clinicopathologic analysis of 23 patients. *J Oral Maxillofac Surg* 2004; 62: 1203–1208.
33. Pedersen AM, Bardow A, Jensen SB, et al. Saliva and gastrointestinal functions of taste, mastication, swallowing and digestion. *Oral Dis* 2002; 3: 117–129.