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Partial sialoadenectomy for the treatment of benign tumours in the submandibular gland

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Abstract. The conventional treatment for benign tumours arising in the submandibular gland (SMG) has always involved whole gland excision with the tumour. In light of developments in parotid gland functional surgery, this prospective study was performed to evaluate the effectiveness and safety of partial sialoadenectomy (PS) for benign tumours in comparison with conventional total sialoadenectomy (TS). Thirty-one consecutive patients with a preoperative diagnosis of benign tumour in the SMG were included in the study from December 2008 to December 2010. Eleven patients were treated with PS and 20 patients underwent conventional TS. Salivary gland function and surgery-related complications were assessed. No difference in resting saliva flow was found between the two groups before the operation, while this was significantly higher in the PS group than in the TS group at 1 year after surgery ($P = 0.009$). With regard to complications, there was less deformity in facial appearance in the PS group. There was no recurrence in any of the 31 patients during the follow-up period (range 41–82 months). It is believed that this modification to SMG surgery is consistent with the idea of functional and minimal invasive salivary gland surgery. This technique represents a good choice for the management of benign tumours of the SMG for appropriately selected cases.

Key words: partial submandibular sialoadenectomy; functional surgery; benign tumour; salivary gland function; surgical complication.

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Saliva is a very import fluid for oral health. It protects the oral mucosa, prevents dental carries, and maintains the functions of mastication and speech. The submandibular gland (SMG) is mostly responsible for resting salivary flow, accounting for 60–65% of the resting whole saliva.[1,2] The conventional treatment for benign tumours arising in the SMG has been extirpation of the entire gland along with the tumour.[3,4] As a result, the affected SMG is lost and the resting saliva decreases.[5,6]

The partial parotidectomy is well accepted and widely used for the treatment of benign tumours in the superficial parotid gland. Compared with the conventional total superficial parotidectomy, the advantages of the partial superficial parotidectomy include a shorter operation time, reduced facial deformity and incidence of Frey syndrome, and the preservation of most of the gland's function.[7–12]

In light of the success of the partial parotidectomy technique, it was hypothesized that a partial sialoadenectomy might be possible for the treatment of benign

tumours in the SMG. Normally, retaining the integrity of the vascular and ductal system of the remaining SMG is crucial for a successful treatment outcome. A previous study by this research group on the microanatomy of the human SMG, performed by perfusing methacrylate to form resin casts of the blood vessels and ducts, showed a tree-like structure with structures of blood vessels and ducts similar at each level in the lobules.[13] This characteristic tree-like structure provides a solid anatomical basis for the partial submandibular sialoadenectomy. Moreover, the research groups of Roh and Park[14] and Ruan et al.[15] each reported a series of 20 patients with pleomorphic adenoma in the SMG treated with gland-preserving surgery. The results showed similar advantages to the partial parotidectomy, including preservation of salivation, reduced surgical morbidity and operating time, and good cosmetic appearance, but without compromising local control.

The purposes of this comparative study were to further investigate the feasibility, safety, advantages, indications, and contraindications of the partial sialoadenectomy for the treatment of benign tumours in the SMG.

Patients and methods

This study was approved by the ethics committee for human experiments of Peking University School and Hospital of Stomatology.

Patients

Thirty-one patients with a preoperative diagnosis of benign tumour of the SMG, attending the department of oral and maxillofacial surgery of the study hospital for treatment between December 2008 and December 2010, were included in this study. All patients provided signed informed consent for the operation.

Before surgery, all patients underwent ultrasound or computed tomography (CT) examination. The imaging appearances of the tumours were consistent with benign solid tumours. A preoperative diagnosis of primary benign tumour of the SMG was achieved based on the combination of case history, clinical examination, and imaging evaluation. Any patient with signs of malignancy or a cyst was excluded from the study.

CT scan

CT scans were performed using an 8-slice scanner (BrightSpeed; GE Medical Systems Waukesha, Wisconsin, USA) with patients in the supine position and the canthomeatal line perpendicular to the floor. The CT scans were carried out with a rotation time of 1 s, pitch of 1.375:1, collimation of 1.25 mm, voltage of 120 kV to 140 kV, and automatic exposure control. Axial images of the parotid and SMGs with a slice thickness of 1.25 mm were reconstructed using a soft tissue algorithm. The diagnosis of a benign tumour of the SMG was based on the judgement of an experienced radiologist and a maxillofacial surgeon.

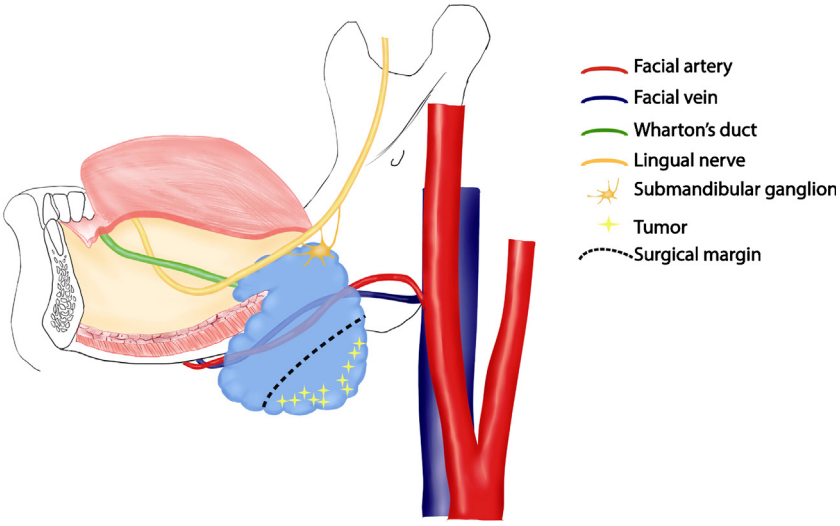

Fig. 1. Diagram of the partial submandibular sialoadenectomy: the extent of resection.

Treatment assignment

The patients were divided into two groups based mainly on the location of the tumours, according to their appearance on CT. Patients in whom the tumours were located in the lateral part of the SMG (including superficial, posterior, and deeper, but not anterior) and far away from Wharton's duct (Figs 1 and 2a) were assigned to the partial sialoadenectomy (PS) group. The other cases were assigned

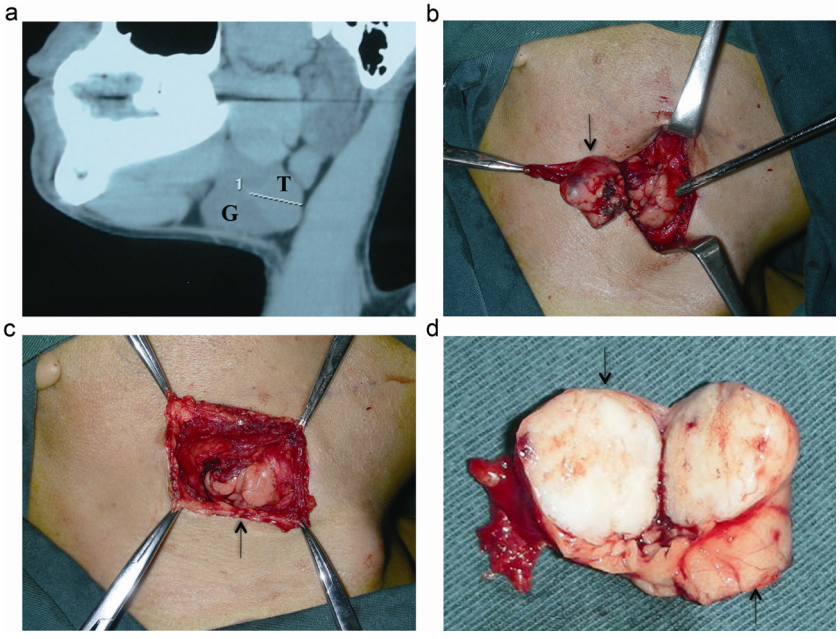

Fig. 2. The procedure of partial submandibular sialoadenectomy. (a) CT scan showing the tumour location (T, tumour; G, submandibular gland). (b) Dissection of the whole tumour with a safe tumour-free margin of surrounding normal gland tissue. (c) Enclosure of the capsule of the residual gland to prevent salivary fistula. (d) The tumour sample surrounded by limited normal gland tissue (downward arrow indicates the tumour; upward arrow indicates the submandibular gland tissue).

to the conventional total sialoadenectomy (TS) group.

Surgical procedures

The transcervical approach was used for all patients. An incision was made in the natural skin crease overlying the SMG, which was 2.5–3.0 cm below the lower border of the mandible.

In the conventional TS group, standard excision of the SMG and tumour was performed as usual. In the PS group, the routine procedure for exposure of the SMG was performed. The facial artery and vein were preserved when the tumour was located in the superficial part of the gland. When the tumour was located in the posterior or the deeper parts of the gland, close to the proximal facial artery and vein, the facial artery and vein were ligated proximally and cut, while the distal facial vessels were carefully preserved. Therefore, the gland was supplied via retrograde flow through the distal facial vessels. The whole tumour was carefully dissected with a safe tumour-free margin of surrounding normal gland tissue of more than 0.5 cm (Fig. 2b, d). During dissection of the surrounding normal gland tissues, a lobectomy was performed if possible in order to maintain the relative integrity of the remaining SMG and prevent salivary fistula. Wharton's duct and the lingual nerve were not exposed.

A frozen section was used to identify the nature of the tumour. During the operation, the tumour and partial SMG tissue or the whole SMG was extirpated as a whole. Investigation of the tumour sample was performed by non-surgical staff on a back table and the entire procedure followed the tumour-free principle. In this way, there was no possibility of tumour capsule rupture and contamination of the surgical bed, thus avoiding tumour seeding. When the frozen section result identified a malignancy, except for malignant lymphoma, the operation would be extended to the removal of the whole SMG. When the frozen section result identified a benign tumour, the operation would be ended with careful enclosure of the surface of the cut gland edge in order to prevent salivary fistula formation postoperatively (Fig. 2c).

A drainage rubber or tube was inserted in the surgical bed in all cases after the operation and was removed within 24–48 h postoperative, depending on the amount of exudate from the wound. Complications were evaluated on the first day postoperative and recorded until recovery during follow-up every 3 months.

Collection of whole saliva

Salivary gland function was evaluated by measuring the saliva flow rate before the operation and at 1 year after surgery. Saliva samples were collected at 9:00 to 11:00 a.m., in an air-conditioned room, where the room temperature was kept at 20–24 °C and humidity was kept at 40–70%. Subjects were asked to refrain from eating, drinking, smoking, and brushing their teeth for at least 90 min before collection.

Before collection, the subjects were instructed to rinse their mouths with water and then to rest for 5 min with their eyes open and head tilted slightly forward. By using the spitting method, whole saliva at rest was collected for 5 min into a preweighed cup. After 5 min of rest, stimulated whole saliva was collected by smearing 2.5% citric acid solution on the lateral side of the tongue with a swab every 30 s for another 5 min. By defining the specific gravity of saliva as 1 g/ml, flow rates were calculated and recorded in ml/min.

Technetium 99m (^{99m}Tc) scintigraphy

Salivary gland function was also evaluated by scintigraphy at 1 year after surgery. ^{99m}Tc scintigraphy using Hawkeye SPECT equipment (Infinia Hawkeye 4, GE Healthcare Waukesha, Wisconsin, USA) was undertaken using a standardized protocol.

The period from stimulation using 2.5% citric acid solution to the minimum value after stimulation within 30 min was considered to be the 'secretion phase'. The secretion index (SI) was calculated using the following formula: SI = (maximum value before stimulation using citric acid − minimum value after stimulation using citric acid)/(maximum value before stimulation using citric acid − background) × 100%.

Data analyses

SPSS for Windows version 13.0 (SPSS Inc., Chicago, IL, USA) was used for the data analysis. Descriptive data were expressed as the mean ± standard deviation (SD). Fisher's exact test was used to compare the proportions of complications and Student's *t*-test was used to compare the within-group and between-group means. A *P*-value of less than 0.05 was accepted as statistically significant.

Results

A total of 31 patients were enrolled in the study: the PS group comprised 11 patients, while the conventional TS group comprised 20 patients. The patients' clinical data are shown in Table 1. The final diagnosis in all patients was a benign tumour.

The operations of the 11 patients in the PS group all went smoothly, as designed preoperatively. The frozen section diagnosis of these patients was pleomorphic adenoma in 10 cases and basal cell adenoma in one case. The final diagnosis was confirmed by examination of paraffin-embedded sections.

The whole saliva flow before and after the operation for the two groups of patients are given in Table 2. There was no difference in the resting saliva flow between the two groups before the operation ($P = 0.798$). However, the resting saliva flow rate in the PS group was significantly higher than that in the conventional TS group at 1 year after the operation ($P = 0.009$). No difference was found in stimulated saliva flow rate before or after the operation ($P = 0.515$, $P = 0.187$) between the two groups. The postoperative resting saliva flow rate in the TS group was significantly lower than the flow rate preoperative ($P < 0.001$).

Table 1. Clinical data of the patients.

	Surgical group	
	Partial sialoadenectomy	Total sialoadenectomy
Number of patients	11	20
Age, years, mean (range)	34.8 (17–51)	56.5 (36–74)
Sex		
Male	4	11
Female	7	9
Pathology		
Pleomorphic adenoma	10	18
Basal cell adenoma	1	1
Myoepithelioma	–	1
Follow-up, months, mean (range)	67.8 (41–82)	60.4 (42–80)

Table 2. Submandibular gland function before the operation and at 1 year after the operation; mean ± SD values.

	Partial sialoadenectomy (PS)		Total sialoadenectomy (TS)	
	Preoperative	Postoperative	Preoperative	Postoperative
Resting saliva flow, ml/min	0.73 ± 0.36	0.63 ± 0.30[a]	0.75 ± 0.40[b]	0.39 ± 0.18[a,b]
Stimulated saliva flow, ml/min	1.47 ± 0.39	1.38 ± 0.47	1.43 ± 0.42	1.25 ± 0.41

SD, standard deviation.

[a] $P = 0.009$, comparison of postoperative resting saliva flow between the PS group and the TS group; significant difference. Other between-group comparisons: $P > 0.05$.

[b] $P < 0.001$, comparison of preoperative and postoperative resting saliva flow in the TS group; significant difference. Other within-group comparisons: $P > 0.05$.

^{99m}Tc scintigraphy showed the salivary secretion index of the affected SMG to be similar to that of the unaffected contralateral SMG, 40.80 ± 12.76% and 49.60 ± 17.21%, respectively ($P = 0.385$), at the time of the 1-year follow-up examination (Fig. 3).

No nerve injury complications were found in the PS group, while there were two cases (10%) of transient mild injury to the marginal mandibular branch of the facial nerve and two cases (10%) of lingual nerve injury in the conventional TS group (Table 3). Nerve function recovered within 3 months in all cases. No patient in the PS group suffered from dry mouth, while seven patients (35%) in the conventional TS group reported dry mouth; this difference was statistically significant ($P = 0.027$). The presence of a sunken facial skin deformity was more obvious in the conventional TS group than in the PS group ($P = 0.027$). No fistula formation was found in either group.

There was no tumour recurrence during a mean follow-up period of 67.8 (range 41–82) months in the PS group and 60.4 (range 42–80) months in the conventional TS group.

Discussion

Benign tumours of the SMG represent a relatively common entity in the oral and maxillofacial field. The conventional treatment modality is total sialoadenectomy with the tumour. Following this treatment, the resting saliva flow is decreased and the symptom of xerostomia may occur because the SMG contributes greatly to the whole saliva in the resting condition. Other surgical complications such as temporary nerve injury and sunken facial tissue may occur, although their incidences are low. While some modifications have been made, such as changing the approach for the incision from the transcervical region to the submental region in order to make it less visible,[16] or changing the approach to intraoral in order to prevent a scar on the skin and thus obtaining better aesthetic results,[17,18] the modality of sialoadenectomy has not been well investigated.

Roh and Park first reported the results of gland-preserving surgery in a series of 20 patients with pleomorphic adenoma of the SMG.[14] Ruan et al. reported the results of a case–control study performed to evaluate the efficacy of gland-preserving surgery for benign tumours of the SMG.[15] Both groups showed multiple advantages of gland-preserving surgery over the conventional total sialoadenectomy. In the present study, the results also showed the advantages of partial sialoadenectomy. The secretion function of the affected SMG was preserved, and the resting whole saliva flow rate was significantly higher than that obtained after conventional total sialoadenectomy. Moreover, surgical complications such as the incidence of

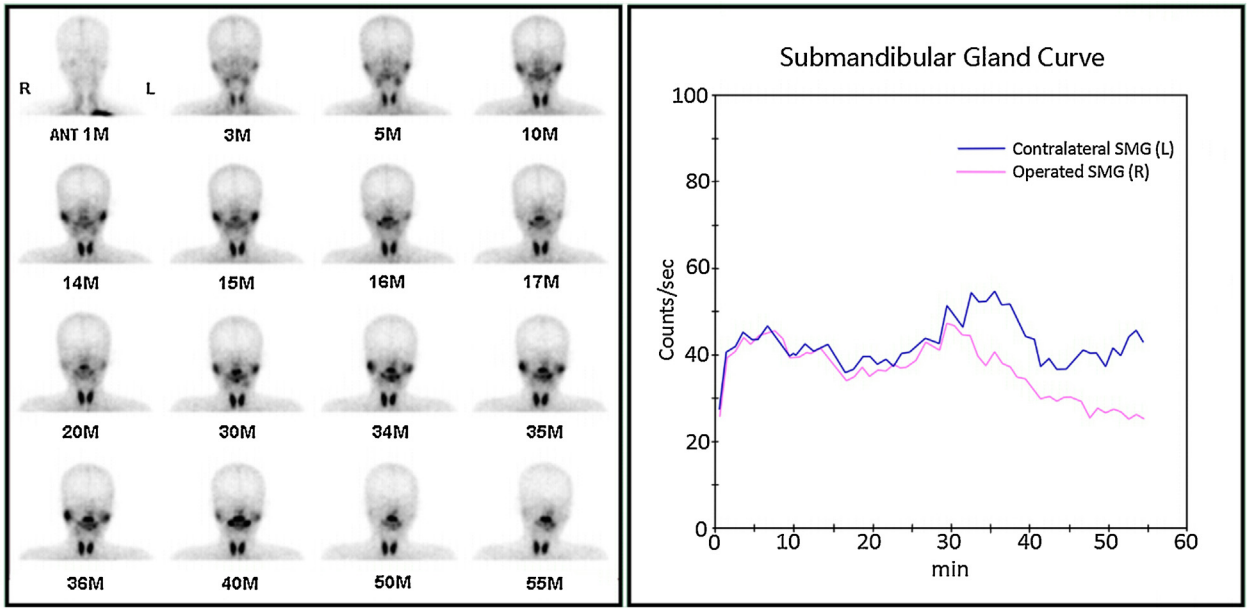

Fig. 3. Scintigram of a patient who had undergone a partial submandibular sialoadenectomy, obtained at 1 year after the operation. The uptake and excretion in the operated submandibular gland (right side) was similar to that in the normal submandibular gland (left side).

Table 3. Complications after submandibular sialoadenectomy.

Complications	Partial sialoadenectomy, *n* (%)	Total sialoadenectomy, *n* (%)	*P*-value
Haematoma	0	0	–
Injury to the marginal mandibular branch of the facial nerve			
Temporary	0	2 (10%)	0.508
Permanent	0	0	–
Transient numbness of the tongue	0	2 (10%)	0.508
Hypoglossal nerve injury	0	0	–
Local sunken deficit	0	7 (35%)	0.027[a]
Infection	0	0	–
Saliva leakage (fistula)	0	0	–
Dry mouth	0	7 (35%)	0.027[a]

[a] Significant difference.

nerve injury and sunken facial tissue were decreased. This is very important to maintaining oral health and improving the quality of life.

The safety of partial sialoadenectomy for the treatment of benign tumours is the most important point in the evaluation of the rationale for this technique. In the studies of Roh and Park[14] and Ruan et al.,[15] there was no recurrence of the tumour. In the present series, no tumour recurrence was identified during a mean follow-up period of 67.8 (range 41–82) months in the PS group. A recent clinical review by Douville and Bradford reported the average recurrence time of pleomorphic adenoma to range from 6.1 to 11.8 years postoperatively.[19] The duration of follow-up in the two previous studies,[14,15] as well as in the present research, was around 5 to 6 years, which is relatively short. Therefore, longer term follow-up is necessary to confidently draw more definitive conclusions.

The indications and contraindications of the technique of partial sialoadenectomy have not been greatly discussed. It is well accepted that malignancy of the SMG is a contraindication to the use of this technique. Roh and Park indicated that gland-preserving surgery seems to have no limitations with regard to the size or location of the pleomorphic adenoma.[14] In the study by Ruan et al., the inclusion criteria were the presence of a primary benign tumour of the SMG sited at the base or tail of the gland on preoperative imaging.[15] In our experience, the location of the benign tumour is critical when the modality of partial sialoadenectomy is selected. The integrity of the vascular and ductal system of the remaining SMG will be damaged after partial sialoadenectomy if the tumour is located in the centre part of the SMG. Wharton's duct will be damaged if the tumour location is close to the duct. It is common for a benign tumour located in the lateral part of the SMG to project into the normal surrounding tissues. In this situation it is not difficult to perform a partial sialoadenectomy. Therefore the size of the tumour is not a limitation of this technique. The following indications for partial sialoadenectomy are suggested: (1) primary benign tumour in the SMG, and (2) tumour located in the lateral part of the SMG and far away from Wharton's duct. The suggested contraindications of this technique are as follows: (1) malignancy of the SMG, and (2) tumour located in the centre part of the SMG or close to Wharton's duct. Based on the importance of tumour location, a preoperative CT scan is essential to locate the tumour in the SMG.

It is understood that a malignancy may be found in patients with a preoperative diagnosis of benign tumour in the SMG based on clinical and imaging examinations. Two of the 20 patients in the study by Ruan et al. were found to have a malignancy, including malignant pleomorphic adenoma and malignant lymphoma. In the present study, a case of malignant lymphoma and a case of partial malignant transformation in pleomorphic adenoma were found, and these cases were excluded from the study. For a more accurate preoperative diagnosis, magnetic resonance imaging (MRI) and fine needle aspiration cytology (FNAC), if possible guided by ultrasound or CT, are suggested, and frozen section examination during the operation is necessary. A wide variation in the accuracy, sensitivity, and specificity of FNAC for the detection of malignant tumours in the salivary gland has been shown in different studies.[20] This is also the case with frozen section.[21] Some studies have found FNAC to be more sensitive and frozen section to be more specific, but both provide a similar accuracy.[22,23] Therefore it is very important to follow the final histopathological diagnosis. In the case of inconsistency with the preoperative diagnosis, the proper treatment should be done according to the final results.

The modality of partial sialoadenectomy may be changed if a frozen section diagnosis of malignancy is made, except in the case of malignant lymphoma. However, the localized malignant transformation of pleomorphic adenoma, also termed 'carcinoma in situ', may occur. The malignant part of the tumour may be missed during the frozen section examination due to sampling. If the malignancy is confirmed by paraffin section diagnosis, then further treatment will be necessary. Neck dissection with or without postoperative radiotherapy should be considered if the tumour is a high grade malignancy. Neck dissection or radiation therapy alone is suggested for the patient with a low grade malignancy. Chemotherapy is a choice for the treatment of malignant lymphoma. Further surgery is unnecessary and the function of the remaining SMG can be preserved.

The results of the present study show that partial sialoadenectomy is a reliable and safe surgical modality for patients with a primary benign tumour located in the lateral parts of the SMG. The partial sialoadenectomy is consistent with the idea of minimal invasive surgery and functional therapy and has several potential advantages over the conventional total sialoadenectomy. However, this study included a limited number of cases. A larger sample of cases with long-term follow-up is necessary to draw more definitive conclusions.

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Competing interests

All authors have no conflict of interest to declare.

Ethical approval

The study was approved by the Ethics Committee for Human Experiments of Peking University School and Hospital of Stomatology.

Patient consent

All patients provided signed informed consent for the operation.

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References

1. Humphrey SP, Williamson RT. A review of saliva: normal composition, flow, and function. *J Prosthet Dent* 2001;**85**:162–9.
2. Diaz-Arnold AM, Marek CA. The impact of saliva on patient care: a literature review. *J Prosthet Dent* 2002;**88**:337–43.
3. Laskawi R, Ellies M, Arglebe C, Schott A. Surgical management of benign tumors of the submandibular gland: a follow-up study. *J Oral Maxillofac Surg* 1995;**53**:506–8.
4. Illes RW, Brian MB. A review of the tumors of the salivary gland. *Surg Gynecol Obstet* 1986;**163**:399–404.
5. Hald J, Andreassen UK. Submandibular gland excision: short and long-term complications. *J Otorhinolaryngol Relat Spec* 1994;**56**:87–91.
6. Springborg LK, Moller MN. Submandibular gland excision: long-term clinical outcome in 139 patients operated in a single institution. *Eur Arch Otorhinolaryngol* 2013;**270**:1441–6.
7. Yamashita T, Tomoda K, Kumazawa T. The usefulness of partial parotidectomy for benign parotid gland tumors. A retrospective study of 306 cases. *Acta Otolaryngol Suppl* 1993;**500**:113–6.
8. Zhao K, Qi DY, Wang LM. Functional superficial parotidectomy. *J Oral Maxillofac Surg* 1994;**52**:1038–41.
9. Rea JL. Partial parotidectomies: morbidity and benign tumor recurrence rates in a series of 94 cases. *Laryngoscope* 2000;**110**:924–7.
10. Johnson JT, Ferlito A, Fagan JJ, Bradley PJ, Rinaldo A. Role of limited parotidectomy in management of pleomorphic adenoma. *J Laryngol Otol* 2007;**121**:1126–8.
11. Roh JL, Kim HS, Park CI. Randomized clinical trial comparing partial parotidectomy versus superficial or total parotidectomy. *Br J Surg* 2007;**94**:1081–7.
12. Emodi O, El-Naaj IA, Gordin A, Akrish S, Peled M. Superficial parotidectomy versus retrograde partial superficial parotidectomy in treating benign salivary gland tumor (pleomorphic adenoma). *J Oral Maxillofac Surg* 2010;**68**:2092–8.
13. Xu H, Mao C, Liu JM, Peng X, Zhu ZH, Yu GY. Microanatomic study of the vascular and duct system of the submandibular gland. *J Oral Maxillofac Surg* 2011;**69**:1103–7.
14. Roh JL, Park CI. Gland-preserving surgery for pleomorphic adenoma in the submandibular gland. *Br J Surg* 2008;**95**:1252–6.
15. Ruan M, Zhang Z, Li SY, Yang WJ, Sun J, Zhang CP. 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**:615–9.
16. Roh JL. Removal of the submandibular gland by a submental approach: a prospective, randomized, controlled study. *Oral Oncol* 2008;**44**:295–300.
17. Hong KH, Kim YK. Intraoral removal of the submandibular gland: a new surgical approach. *Otolaryngol Head Neck Surg* 2000;**122**:798–802.
18. Weber SM, Wax MK, Kim JH. Transoral excision of the submandibular gland. *Otolaryngol Head Neck Surg* 2007;**137**:343–5.
19. Douville NJ, Bradford CR. Comparison of ultrasound-guided core biopsy versus fine-needle aspiration biopsy in the evaluation of salivary gland lesions. *Head Neck* 2013;**35**:1657–61.
20. Nguansangiam S, Jesdapatarakul S, Dhanarak N, Sosrisakorn K. Accuracy of fine needle aspiration cytology of salivary gland lesions: routine diagnostic experience in Bangkok, Thailand. *Asian Pacific J Cancer Prev* 2012;**13**:1583–8.
21. Tan LG, Khoo ML. Accuracy of fine needle aspiration cytology and frozen section histopathology for lesions of the major salivary glands. *Ann Acad Med Singapore* 2006;**35**:242–8.
22. Seethala RR, LiVolsi VA, Baloch ZW. Relative accuracy of fine-needle aspiration and frozen section in the diagnosis of lesions of the parotid gland. *Head Neck* 2005;**27**:217–23.
23. Zbären P, Nuyens M, Loosli H, Stauffer E. Diagnostic accuracy of fine-needle aspiration cytology and frozen section in primary parotid gland carcinoma. *Cancer* 2004;**100**:1876–83.

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