Parotid gland tumours

diagnostics, surgical aspects, follow-up, and suggestions

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(met een samenvatting in het Nederlands)

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Voor mijn ouders

Een wijs zoon verheugt zijn vader, maar een dwaas zoon is een bekommering voor zijn moeder. Spreuken 10:1

Contents

1

General introduction and aim of the study

Introduction

Tumours of the parotid gland, which account for 3% of all head and neck tumours, form a heterogeneous group. It comprises more than 30 different types of benign and malignant tumours. These neoplasms pose a challenge to the pathologist. First, it is hard to classify them, as they may exhibit a broad spectrum of morphologic diversity. Secondly, the diagnosis often has to be based upon the cytology. About 80% of the parotid neoplasms are benign, the most common of which is pleomorphic adenoma. Between 70 and 80% of all benign tumours are of this type. Although benign, this kind of tumour can grow progressively and could degenerate into a malignancy. Therefore, surgery is advised in most cases.[1,2]

When performing a radical excision, the surgeon tries to preserve the facial nerve (N VII), an outcome of great importance to the patient. This preservation effort makes parotid gland surgery a strenuous exercise for the operating surgeon.
Parotid gland surgery usually starts with the identification of the main trunk of the facial nerve as it leaves the base of the skull at the stylomastoid foramen. For this anterograde procedure, the upper border of the posterior belly of the digastric muscle and its attachment to the mastoid process often serves as a landmark for locating the main trunk of the facial nerve. Another landmark is the 'pointer', a portion of the tragal cartilage that points in the direction of the nerve. According to some authors, the closest of the constant and easily identifiable landmarks is the tympanomastoid suture.[3,4,5,6,7]

The facial nerve divides the gland in a superficial lobe (about 80 to 85% of the gland) and a deep lobe.[8,9] Parotid gland tumours occur equally in the tissue of both lobes. Thus, the majority of the parotid tumours are located superficial to the facial nerve. They are surgically removed by dissecting the tumour, with its surrounding glandular tissue, from the facial nerve trunk and its branches. This procedure is known as partial superficial parotidectomy (PSP). PSP is the technique most often used for both benign and low-grade malignant tumours. Superficial parotidectomy, during which the whole superficial lobe is removed, is unnecessary, both in our opinion and according to the literature. This is because the margin of resection is generally determined by the shortest distance from the tumour to the nerve.[10,11,12] A benign tumour in the superficial lobe might have a local extension into the deep lobe between the facial nerve branches. If so, it can usually still be resected without much risk by means of a locally extended PSP. The options for deep lobe tumours are partial

deep lobe parotidectomy, deep lobe parotidectomy, or total parotidectomy. In the event of malignancy, a radical parotidectomy sacrificing the facial nerve might be the only option. Deep lobe surgery requires dissection medial to the facial nerve with more extensive manipulation of its branches. Therefore, during deep lobe surgery, there is a higher incidence of temporary or permanent paresis of the facial nerve. When the physician has prior knowledge of the tumour's location and type, he or she can discuss the implications of surgery with the patient, providing information about the procedure and the potential risk of damage to the facial nerve. Prior knowledge can also help the physician assess how urgent it is to operate and how much time is needed for surgery. Thus, prior knowledge might also help with the scheduling of surgery.

Pre-operative patient counselling is an important activity at the outpatient clinic. To maximize its effect, the radiologist and cytopathologist must take part in forming the pre-operative diagnosis. It has been recommended that readily palpable masses, located with some degree of certainty within the substance of the parotid gland, may be appropriately managed without imaging or fine needle aspiration cytology (FNAC). Yet for less definite lesions, many think that these techniques can be of great help in planning the treatment.[11,13] Hence, patients visiting our hospital for a parotid gland tumour will undergo both MRI and ultrasound (US) with US-guided FNAC before going into surgery. However, these imaging techniques do not visualize the facial nerve in the parotid gland. So far, several landmarks for predicting the course of the facial nerve in the gland have been described. During our first study, we noted a consistent relationship between the facial nerve and the retromandibular vein. This close relation has been described by others as well.[14] We therefore expected this anatomic structure to be helpful in predicting the course of the facial nerve main trunk within the parotid gland.

The literature mentions several complications of parotid gland surgery: recurrence of tumour, facial nerve paresis, salivary fistula, and gustatory sweating (Frey's syndrome). Most patients will also experience numbness in the earlobe and the pre-auricular skin. This is a direct result of cutting through the cutaneous branches of the great auricular nerve when making the incision. In the case of a benign parotid gland tumour, today the risk of permanent paresis of the facial nerve is low. Few patients at our outpatient clinic have Frey's syndrome. In contrast, the literature reports that Frey's syndrome is found in more than half of the patients

following parotidectomy when they are tested using the starch-iodine test described by Minor.[15]

The aetiology of parotid tumours is not well understood. Smoking and drinking habits have been extensively studied in relation to most types of head and neck tumours. There seems to be no relation between the well-known enhancing environmental or behavioural factors and the occurrence of parotid gland tumours. We did notice, however, that Warthin's tumour (papillary cystadenoma lymphomatosum), the second most common benign tumour of the parotid gland, develops almost exclusively in patients who are heavy smokers.

Up till now, facial nerve paresis/paralysis is still reported and documented according to the House-Brackmann Grading Scale (HBGS) for facial nerve disorders. This system is universally accepted, and its use is required by the Facial Nerve Disorders Committee of the American Academy of Otolaryngology - Head and Neck Surgery.[16] While evaluating the post-operative results of our patients, it was not always easy to assign the patients to one of the six categories of the HBGS. Notably in the case of a patient with one paralysed region of the face and a normal function of the rest, it was difficult to make a correct classification.

This thesis

The first study shows how we determined which of the various landmarks described in the literature is the best one for identifying the main trunk of the facial nerve (see Chapter 2).

The next two chapters describe a new method for predicting the location of parotid gland tumours using the retromandibular vein as a landmark (see Chapter 3 and 4).

Then, in order to evaluate the traditional standard pre-operative programme of care for patients with parotid gland tumours, we assess the usefulness of US, MRI, and FNAC for differentiating subtypes of tumours and for predicting the location of a tumour relative to the facial nerve (see Chapter 5).

Next, we evaluate the results of our surgical interventions in order to study the different sequellae of surgery more adequately (see Chapter 6).

Since only a small percentage of our patients developed Frey's syndrome, we take a closer look at the pathophysiology and the prevention of this syndrome (see Chapter 7).

We performed a literature study and an analysis of the medical records of our patients to verify our observation that Warthin's tumour seems to be related to smoking (see Chapter 8).

Finally, we present a more regionally based classification system for facial nerve disorders. This system is currently being tested at our institute. Hopefully, it will prove to be reliable, reproducible, and easy to use. It is intended to facilitate the follow-up of patients post-operatively after parotid gland surgery, but it may also be useful in cases of paresis/paralysis due to other disorders of the N VII (see Chapter 9).

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2

Landmarks for parotid gland surgery

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Introduction

It is essential to incorporate facial nerve identification in the technique for parotid gland surgery. Only after identifying the most important structures can the surgeon avoid injury to them.[1,2] Of course, the surgeon must be familiar with the various techniques available in order to respond to variations in the pathology that make any particular approach difficult. Nonetheless, it would be very helpful to develop a precise and generally applicable procedure, using constant anatomic landmarks, to identify the facial nerve quickly.

Over the past century, various anatomic landmarks have been used to identify the facial nerve. At first a retrograde technique was used, whereby the surgeon first identified a muscular branch of the facial nerve, then performed retrograde dissection, and finally identified the main trunk.[3,4]/ Sistrunk, in 1922, located the nerve by initially identifying the marginal mandibular branch. Adson and Ott extended this method by exposing and dissecting the temporal division. In the fifties, McNealy and McCallister used the buccal branch as a key to the depth of the proximal divisions of the facial nerve. Bailey identified the temporal branches where they obliquely cross the zygomatic arch.[5] This is a time-consuming technique, especially for large tumours, when the intraparotid facial nerve plexus has been distorted by bulky infiltrating tumours or by scarring due to previous procedures.[6] Therefore, the retrograde technique has been abandoned for the most part.[7] However, the surgeon who performs parotid surgery should still be familiar with it, because he or she may still have to resort to this method under certain circumstances.[5]

Janes, in 1940, was the first to describe the exposure of the nerve at its exit from the stylomastoid foramen.[5] In this anterograde procedure, the surgeon generally uses the upper border of the posterior belly of the digastric muscle and its attachment to the mastoid process to identify the main trunk of the facial nerve.[1,6,8,9] The nerve is found approximately 1.5 cm anterocranial to this point and about 2 cm below the skin.[6,10,11,12] In 20 specimens Holt found the nerve at the stylomastoid foramen lying 9 mm, on average, from the digastric muscle.[13] While Robertson used this landmark as an additional guidance for the depth of the incision, he thought that it was too variable to serve as a leading landmark.[7]

Another landmark is the 'pointer', a portion of the tragal cartilage pointing in the direction of the nerve.[1,9,14] The nerve lies 1 to 2 cm deeper than the pointer.[1,9] On MR images the

main trunk lies 10 to 15 mm caudal to the pointer.[14] Robertson did not think highly of the pointer, however. It is difficult to decide where the cartilage points: not only is it mobile and asymmetrical but it has a blunt, irregular tip.[7]

Brintnall found the main trunk of the nerve between two bony landmarks: 1) superiorly, the sharp, fingernail-like bony ridge at the anteroinferior margin of the external auditory meatus of the skull; and 2) inferiorly, the broad, blunt anterior margin of the mastoid process of the temporal bone. There is a V-shaped sulcus between these two bony landmarks, and close to this sulcus lies the main trunk of the nerve. Once the surgeon reaches the sulcus, the nerve cannot be more than 2 to 3 mm deeper.[15] Brintnall makes one of the first references to the fissura tympanomastoidea (tympanomastoid suture) and calls the region the 'valley' of the nerve. The nerve is usually situated at a depth of 0.5 to1.0 cm beneath the bony rim. According to some authors, this landmark is the most reliable of all.[1,7,8,10,16,17] It is (1) easy to find, (2) remains fixed in position, (3) has a reliable relationship with the nerve because it leads to the stylomastoid foramen, and (4) allows the nerve to be identified close to the foramen where it is least subject to displacement.[7] Hogg and Kratz found the facial nerve located 6 to 8 mm medial to this landmark. They state that the stylomastoid foramen is located 1.0 cm medial to the inferior lateral margin of the tympanomastoid suture.[17] In their series of 120 half skulls, the average distance between the inferior lateral margin or 'drop-off point' of the tympanomastoid suture and the stylomastoid foramen at the base of the skull was 7.2 mm. They found the main trunk in the fat pad even more superficially than the depth of the stylomastoid foramen (approximately 3 to 6 mm). Therefore, the drop-off point of the tympanomastoid suture is the closest of the constant and easily identifiable landmarks used to locate the main trunk of the facial nerve.[6] Robertson, however, found it difficult to find the drop-off point. He suggested using the most lateral point of the fissure, which is 7 to 15 mm from the foramen. Reid found the nerve 3 to 4 mm from this bony edge.[9] Browne was rather sceptical of this new landmark, finding it very hard to understand how one could feel the "vaginal process of the tympanic bone" without performing unnecessary dissection in an area where "hazards await the unwary". Another drawback is that the tympanomastoid suture is obscured by the strong tendon of the sternocleidomastoid muscle, which is inserted into the lateral surface of the mastoid process from its apex to its superior border. In Browne's opinion, one would need extremely sensitive fingers feel these rather tenuous structures.[18] Browne prefers the technique described by Beahrs as follows. A fingertip is placed on the lateral surface of the mastoid process, pointing directly forward. The trunk of the facial nerve

will be found to be deep and slightly anterior to the centre of the fingertip so placed. Thus the operator's critical attention may be focused on a zone of about 1 cm.[19] Heeneman describes a similar technique. One index finger is placed flush with the lowermost tip of the mastoid process on top of and parallel to the fibres of the sternocleidomastoid muscle. The other index finger is placed on the lateral surface under an angle of 90 degrees with the first finger, and in doing so, it points directly forward. The trunk of the facial nerve will be found to be deep and slightly anterior to the centre of the fingertip so placed.[5] Robertson, however, thinks this is only a rough guide.[7]

The styloid process was also used as a landmark.[1] This is not considered reliable because it lies too deep and anterior.[7,8,17,19,20] The nerve crosses superficial to the styloid, so when the surgeon reaches the styloid process he is already deeper than the nerve.[2,7] Furthermore, according to Beahrs, the styloid process is absent in 30% of the cases.[19]

In this study, we tried to determine as objectively as possible which one of the landmarks described in literature is the best. Here, we present the measurements of the distances from the various landmarks to the facial nerve as measured in 30 halves of cadaver heads. Furthermore, we present the subjective assessment of two ENT surgeons of the clinical usefulness of the different landmarks in each case.

Materials and Methods

Thirty facial nerves were dissected in formaldehyde-fixed cadavers. A pre-auricular incision was made. Following the tragal cartilage, the dissection continued until reaching the level of the digastric muscle. Then the facial nerve was identified, and a superficial parotidectomy was performed. Next, the sternocleidomastoid muscle was detached from the mastoid process (Figure 1). Finally, the shortest distances were measured from the main trunk (i.e. from the commencement at the foramen stylomastoideum to the first bifurcation into upper and lower branches) of the facial nerve to the posterior belly of the digastric muscle, to the pointer, and to the tympanomastoid suture.

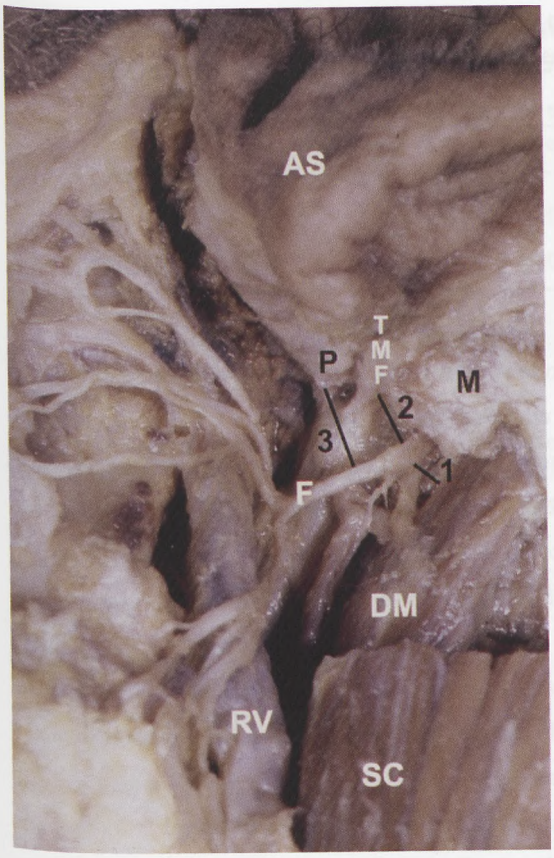

Figure 1. Dissected facial nerve; left side; (infero)-lateral view. AS = auricula sinistra, F = facial nerve, DM = digastric muscle, TMF = tympanomastoid suture, RV = retro-mandibular vein, P = 'pointer', and M = mastoid process, SC = sternocleidomastoid muscle; 1 = shortest distance from the digastric muscle to the main trunk of the facial nerve; 2 = shortest distance from the tympanomastoid suture to the main trunk of the facial nerve; 3 = shortest distance from the 'pointer' to the main trunk of the facial nerve.

The measurements were made by two observers, both anatomists. Pearson's correlation was used to determine whether there was agreement between the observers. After this procedure, two ENT surgeons independently chose the landmark that seemed best in each case. They could choose among the following: a) the pointer; b) the tympanomastoid suture; and c) the posterior belly of the digastric muscle. In addition to these landmarks, they had another option: d) the fingertip method described by Heeneman. These options were ranked on a scale of 1 (best) to 4 in each cervico-facial half by both surgeons. Then the pointer was judged as

pointing to the nerve or not. The Friedman test was used to determine whether there was a significant difference between their preferences. Finally, the relationship between the objective measurements and the subjective scoring was evaluated.

Results

The results of the measurements were as follows. The main trunk of the facial nerve was found at a depth of somewhat more than 3 cm under the skin (see Table 1). The mean distance from the pointer to the main trunk of the facial nerve was 8 mm. The average shortest distance from the digastric muscle to the main trunk of the facial nerve was on average 4.5 mm. The tympanomastoid suture had an average shortest distance to the nerve of 2.7 mm (see Table 2). The 'pointer' did point to the main trunk of the facial nerve in 20% of the cases (Figure 2). If the pointer was the preferred landmark, its distance to the nerve ranged from 2.6 to 10.1 mm. If it was not the preferred landmark, however, its distance to the nerve was in a range of 6.2 to 11.2 mm (see Table 2). Furthermore, in only three of the cases, whereby the pointer was the landmark of preference, did it point to the nerve.

Agreement between the two anatomists was significant (at the 0.01 level) for all measurements mentioned above (two-tailed, using Pearson's correlation index, correlation from 0.786 to 0.934). There was considerable agreement between the surgeons with regard to preferences (Figure 3). Furthermore, the difference between preference for the landmarks proved significant using the Friedman test: (FR (x) 43.92) for surgeon 1 and (FR (x) 44.05) for surgeon 2, both $p<0.0005$.

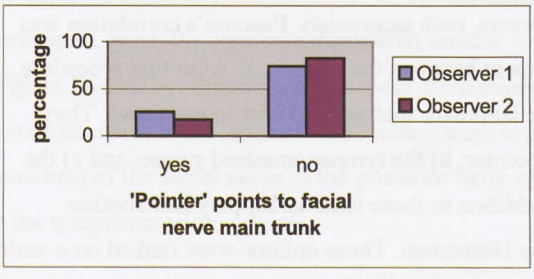

Figure 2. Percentage of cases in which 2 observers agree that the 'pointer' points to the facial nerve main trunk.

Table 1. Mean shortest distance in mm from the skin to the main trunk of the facial nerve; measurements by two observers; 30 halves of cadaver heads.

	Mean distance skin-facial nerve (SD)	
Observer 1	31.4 (4.3)	n = 30
Observer 2	32.4 (3.6)	n = 30

Table 2. Mean shortest distance in mm from A) the 'pointer', B) the digastric muscle, and C) the tympanomastoid suture to the main trunk of the facial nerve (measurements by two observers; 30 halves of cadaver heads).

	Mean shortest distance to the facial nerve (SD)		
Observer 1	A 8.4 (3.6) n = 30	B 4.8 (2.3) n = 29	C 2.7 (.7) n = 29
Observer 2	A 7.3 (2.4) n = 28	B 4.5 (2.3) n = 29	C 2.6 (.8) n = 29

Discussion

This study shows that the tympanomastoid suture is the closest landmark to the main trunk of the facial nerve. As mentioned by Robertson and Blake, it was sometimes difficult to find the drop-off point of the suture.[6] However, in our dissections, the nerve had already been found. Also, each of the ENT surgeons found the tympanomastoid suture to be the most useful landmark. In our clinic, the pointer was regarded as the most useful indicator and, until very recently, was therefore used in surgery. Although the difference is not significant, the 'pointer' is generally considered the best landmark simply because its distance to the nerve is very short (see Table 3). The mean distances for every landmark were alike for the two observers, except for the pointer (see Table 2). This outcome concurs with the findings of Robertson and Blake, who said it was hard to decide where the cartilage points because it is mobile and asymmetrical and its tip is blunt and irregular.[6]

Table 3. Boundaries of the shortest distance in mm from the pointer to the facial nerve for the cases in which the pointer was or was not the preferred landmark; (95% interval; measurements by two observers).

	Observer 1	Observer 2
Lower boundary if pointer was landmark of preference	3.7	2.6
Lower boundary if pointer was not landmark of preference	7.2	6.2
Upper boundary if pointer was landmark of preference	9.7	10.1
Upper boundary if pointer was not landmark of preference	11.2	8.7

Furthermore, there is a wide variation in the means and standard deviations for the distances from the posterior belly of the digastric muscle and from the pointer to the nerve; the variation is probably due to anatomical variability. This strengthens the conclusion that these structures are not the best landmarks. Differences between our findings concerning the distances and the findings of other authors might be due to fixation artefacts. In our opinion, post-mortem artefacts probably influence absolute distances more than relative distances. The artefacts might alter (shorten) the distance, but there is no conclusive evidence that it would affect one distance more than the other.

Based on these findings, the following method of surgery was recently introduced at our clinic. The incision is pre-auricular. The cartilage of the pointer is followed medially. After the pointer has been dissected, a microscope is used for further dissection. Next, the tympanomastoid suture is identified. According to some authors, this structure is the most reliable landmark.[6,10,15] They give the following reasons: it is (1) easy to find, (2) its position is invariable, (3) its relation to the nerve is reliable because it leads to the stylomastoid foramen, and (4) it allows the nerve to be identified close to the foramen, where it is least subject to displacement. According to the results of our study, the nerve lies within 3 mm of this landmark. We find this to be a very practical method.

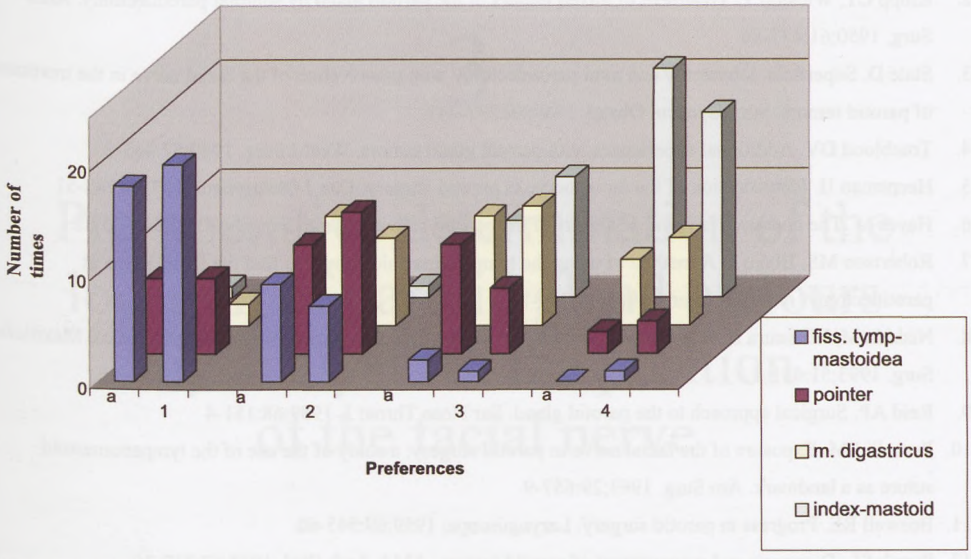

Figure 3. Subjective ranking on a scale of 1 (best) to 4 for four different landmarks: tympanomastoid suture; 'pointer' (tragal cartilage); digastric muscle; one index finger at the lower-most tip of the mastoid and the other at a straight angle at the lateral surface pointing straight forward to the nerve. Ranking by two ENT surgeons.

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3

Pre-operative determination of the location of parotid gland tumours by analysis of the position of the facial nerve

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Introduction

Although the parotid gland is not anatomically divided into lobes, surgeons do distinguish a deep lobe and a superficial lobe separated by the facial nerve and its branches for practical reasons. Neoplasms located in the superficial lobe can be treated by superficial lobectomy, whereas lesions extending into or arising from the deep lobe require total parotidectomy.[1] Superficial lobectomy involves dissection of the facial nerve. The operation has low morbidity in terms of damage to the facial nerve. Total parotidectomy requires complete dissection and elevation of the facial nerve, with or without partial resection of the mandible and sacrifice of the nerve. Because this may produce significant disability, the surgeon should prepare the patient for such an outcome before the operation.[2] Furthermore, pre-operative imaging and identification of the facial nerve and its relation to a parotid tumour may be very helpful in estimating the time required for the operation.[3]

At present, the course of the facial nerve in the parotid gland cannot be visualized with any radiologic technique.[3,4,5] However, several investigators have identified anatomic landmarks for predicting the intraparotid course of the facial nerve on computed tomography (CT). Conn et al. found that the nerve and its branches lie in a sagittal plane approximately 8.5 mm from the most posterior point of the mandibular ramus.[6] Others have attempted to predict the course from anatomic landmarks such as the retromandibular vein (RV), the styloid process, the posterior belly of the digastric muscle, and the Stensen's duct. Kurabayashi et al. used 3 hypothetical lines for indicating the course of the facial nerve.[2,7,8,9,10,11] These lines were drawn on axial CT scans that were made parallel to the Frankfort plane. Although the best line was the one connecting the main facial trunk with the lateral border of the masseter, only 63% of the deep lobe tumours were correctly diagnosed using that line. In cases where both the tumour and the Stensen's duct were demonstrated on the CT sialogram, this line was the best criterion to differentiate deep lobe from superficial lobe tumours. Recently, Ariyoshi and Shimahara proposed a combination of a hypothetical line and an anatomic landmark to assess tumour localization in the parotid gland: 1) a line connecting the lateral surface of the posterior belly of the digastric muscle to the lateral surface of the cortical bone of the ascending ramus (facial nerve (FN) line); and 2) the relationship of the tumour to the RV.[12] If the tumour was located lateral to the FN line, it was designated as superficial; if it was located medial to the FN line, it was designated as deep. When the RV was displaced medially or, although not displaced, the tumour was

located lateral to the RV, it was diagnosed as superficial. Using the FN line criterion, seven out of eight tumours were correctly diagnosed, whereas five out of eight were correctly diagnosed using the RV as a landmark.

In this anatomic study, two hypothetical lines for the location of the facial nerve were compared with the FN line.

Materials and Methods

Transverse sections of five cadaver heads were used in this study. Three of the heads had been formaldehyde-fixed (4%) and sectioned in a cryomicrotome (PMV 450MP, Palmstiernas Instruments AB, Stockholm, Sweden) at –25 °C at 1.5 mm intervals. The chosen thickness for sectioning was 24 μm. Sections were stained with the Mallory-Cason procedure. In this way, 53 usable slices were obtained. Photographs of the slices were taken. The two other heads had been formaldehyde-fixed (4%), frozen, and then sectioned at 1.5 cm intervals using a bandsaw. In this way 16 usable slices were obtained. The lines connecting the most dorsal (line 1) and the most lateral point (line 2) on the ipsilateral half of the vertebra, to the dorsal side of the RV (see Figure 1), plus the FN line, were drawn on the photos of the cryomicrotome slices (see Figure 2) and on the bandsaw sections. Next, the shortest and the longest distance to the nerve, at right angles to the line, were measured on the part of the nerve that was shown. A score of 1 point was given to the line with the shortest distance; the other lines scored no point. If the shortest distance was equal for two or more lines, each received the same score (i.e. 1 point). Each line received a final score for the total number of times it had the shortest distance to the nerve.

The same procedure was followed when measuring the longest distance. Each line received a point if it had the shortest 'longest distance' to the nerve. The individual scores were added, and a final score was obtained.

The results were expressed in a superiority index: the scores of each line for the different measurements (see Tables 1 and 2).

Finally, the number of times that the lines and the nerve crossed each other was scored (see Table 3). In total 69 slices were used. For statistical comparison of the lines the chi-square test was used.

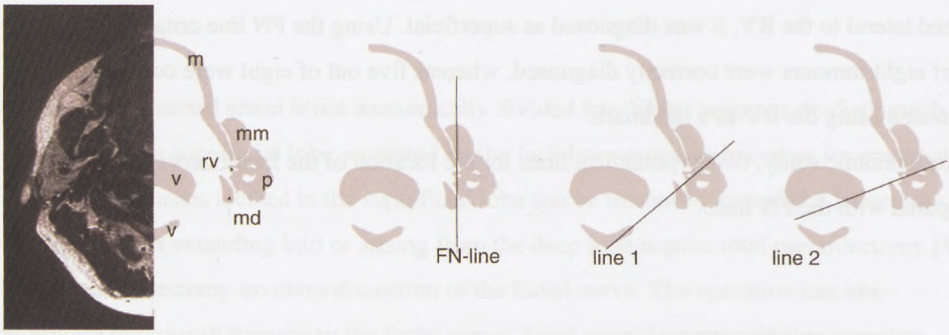

Figure 1. MR Image of the head (axial plane) and schematic drawing of the relevant structures. Three lines are shown: 1) FN line - connecting the lateral surface of the posterior belly of the digastric muscle to the lateral surface of the cortical bone of the ascending ramus; 2) line 1 - connecting the most dorsal point on the ipsilateral half of a vertebra to the dorsal side of the retromandibular vein; and 3) line 2 - connecting the most lateral point on the ipsilateral half of a vertebra to the dorsal side of the retromandibular vein (md = digastric muscle, posterior belly; m = mandible; mm = masseter muscle; p = parotid gland; rv = retromandibular vein; v = vertebra).

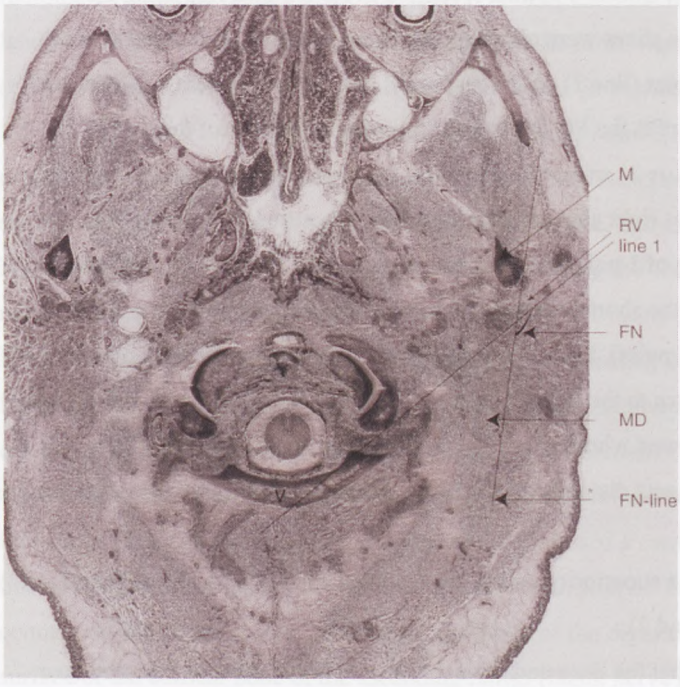

Figure 2. FN line and line 1 as described in Figure 1, drawn on the photograph of a transverse section of a cadaver head (Mallory-Cason stain). Additional colouring of the facial nerve has been added to the photograph (MD = digastric muscle, posterior belly; FN = facial nerve; M = mandible; RV = retromandibular vein; V = vertebra).

Results

As indicated in Table 1, line 1 most often had the shortest distance to the nerve; it had a score of 50. The average shortest distance (based on all sections) for this line is 0.8 mm. The FN line was given 23 points, with an average of 3.3 mm, and line 2 was given 14 points, with an average of 1.4 mm. When line 1 and the FN line were compared, and the slices on which both lines scored a point were left out, line 1 turned out to be the best in 44 cases, whereas the FN line was superior in 16 cases. This difference is highly significant ($\chi^2_1 = 13.1$ ($p < 0.001$)).

The score for the shortest 'longest distance' was 52 for line 1, with an average distance of 2.4 mm. The FN line received 11 points and line 2 received 12 points, with an average of 5.4 and 3 mm, respectively (see Table 2).

When line 1 and the FN line were compared leaving out the slices on which both lines scored a point, line 1 was superior for the shortest 'longest distance', in 58 cases, whereas the FN line was the best in 11 cases. This difference was also highly significant ($\chi^2_1 = 32.0$ ($p<0.001$)).

Table 3 presents the frequency with which each line crossed the nerve. It occurred 33 times for line 1, whereas the FN line and line 2 crossed the nerve 16 and 12 times, respectively.

Table 1. Number of times the shortest distance to the nerve was given points for each of the three lines.

	Shortest distance	
	Cryotome Sections	Bandsaw slices
FN line	16	7
Line 1	39	11
Line 2	14	0

Table 2. Number of times the shortest 'longest distance' was given points for each of the three lines.

	Shortest 'longest distance'	
	Cryotome Sections	Bandsaw slices
FN line	5	6
Line 1	41	11
Line 2	12	0

Table 3. Number of times the line crossed the nerve for each of the three lines.

	Cryotome Sections	Bandsaw slices
FN line	5	6
Line 1	41	11
Line 2	12	0

Discussion

Predicting the relationship of parotid gland tumours to the intraparotid facial nerve is essential. Their relative positions will determine the method and timing of surgery and how the patient should be prepared for it.

Recently, Ariyoshi and Shimahara used the FN line criterion and the RV as landmarks for locating the facial nerve.[11] In this study, the FN line was compared to two other hypothetical lines, one of which seems superior to the FN line.

In a discussion of the Ariyoshi and Shimahara article, Borges and Lufkin made some comments that would pertain to the lines used in this study if they are to be used as a strategy for tracing the course of the facial nerve. It will not always be possible to draw these lines because the vein may not always be clearly visualized. Furthermore, these lines require the relationship between the facial nerve and the structures used as landmarks to be relatively constant in all subjects. Even then, these lines can only be drawn when those structures are clearly visible.[12]

The most dorsal point that is used in line 1 is not constant in all slices and in all subjects, because the whole vertebra is not always shown on a slice. Nonetheless, this study showed that the proposed line 1 determines the position of the nerve in the gland better than the FN line can. Furthermore, the assumption that the new proposed line 1 is better suited to an in vivo situation in the event of displacement of the nerve by a tumour seems justified, because both the tumour and the RV are located within the parotid gland. The accuracy is a result of the constant relation between the nerve and the vein. Both the nerve and the vein will be displaced by a tumour, and so will line 1. However, the mandible and digastric muscle are relatively fixed structures outside the parotid gland and will not be displaced.

Both the average shortest distance and the average longest distance to the nerve were shorter for the proposed line 1 than for the FN line. Moreover, the difference between these two distances was smaller, indicating that line 1 more closely parallels the course of the nerve in the gland.

Like all other methods, this proposed line will not be 100% accurate. However, it could be useful. Therefore, it should be added to the methods used for intraparotid facial nerve localization. The proposed lines in this study can be used on both CT and MRI scans. It is necessary to conduct a prospective clinical study in which the proposed line 1 will be compared to the FN line, taking the findings at surgery as the gold standard.

Acknowledgment

We kindly acknowledge the statistical advice of Dr. A.R.T. Donders.

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4

The location of parotid gland tumours in relation to the facial nerve on Magnetic Resonance Images and Computed Tomography scans

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Introduction

The facial nerve divides the parotid gland into two lobes: a superficial and a deep lobe. When planning surgery, it is important to know where to find the parotid gland tumour in relation to the facial nerve. The location of the tumour can influence the duration and difficulty of the operation. Therefore, prior knowledge allows the physician to adequately prepare the patient for the possible implications of surgery. The patient can then be informed about the length of the procedure and the potential for facial nerve damage.

Unfortunately, neither CT scans nor MR imaging can be used to visualize the facial nerve and its branches in the parotid gland.[1] For this reason, many investigators have tried to find ways to predict the course of the facial nerve in the parotid gland. Conn et al. used an 8.5-mm arc around the dorsal point of the ramus mandibulae.[2] Kurabayashi et al. used a line connecting the main facial trunk to the lateral border of the masseter, whereby only 63% of the deep lobe tumours were correctly diagnosed. This line was drawn on axial CT scans that were made parallel to the Frankfort plane.[3] Ariyoshi and Shimahara used a line connecting the lateral surface of the posterior belly of the digastric muscle to the lateral surface of the cortical bone of the ascending ramus mandibulae (facial nerve [FN] line).[4]
In a recent anatomic investigation, we described a line that better predicts the intraparotid course of the facial nerve than Ariyoshi and Shimahara's FN line. Our proposed Utrecht (U) line connects the most dorsal point visible of the ipsilateral half of a vertebra to the dorsal side of the retromandibular vein (RV).[5] The present study compares the clinical significance of both the FN line and the U line in predicting, retrospectively, the location of parotid gland tumours in 28 patients (15 CT scans and 13 MR images). One objective of the study was to clarify the possible application usefulness of the U line in clinical practice before starting a prospective study to establish the usefulness of this tool.

Materials and Methods

This study is based on a retrospective review of 15 CT scans and 13 MR images. All scans and images were of patients who had been operated upon within the last five years for parotid gland tumours at the University Medical Centre Utrecht or the Hospital Centre Apeldoorn.

There were 28 patients; 15 were women, and their mean age was 50.1 years (age ranges, 21 to 79 years). The location of the tumour was left for 18 patients, right for nine patients, and both (left side operated on) for one patient. Both the FN line and the U line were drawn on the scans. If a tumour was totally or mostly located lateral to the line, it was said to be in the superficial lobe (see Figure 1). If it was totally or mostly medial to the line, it was designated as a deep lobe tumour. If the tumour was divided into roughly equal parts, it was allocated to both lobes, which meant that it might require more than a superficial parotidectomy.

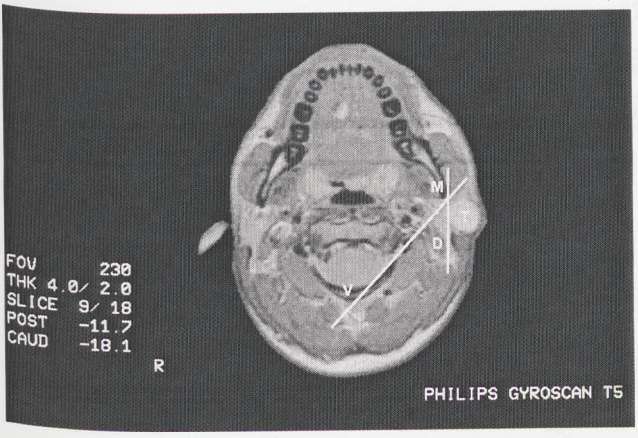

Figure 1. Axial Magnetic Resonance Image of a parotid gland tumour. Both the FN line and the U line are drawn on the scan. The tumour was designated as a superficial lobe tumour since it is located lateral to both lines. At surgery, the tumour was found to be located superficial to the facial nerve. V = vertebra, D = digastric muscle, M = mandible, T = tumour, arrow points to the retromandibular vein.

Our recent anatomic study demonstrates that the U line cannot be used with tumours anterolateral to the RV. We draw this conclusion because the course of the facial nerve changes abruptly beyond the RV. At first, the nerve runs in an anterolateral direction. However, having passed the vein, its course shifts to a more anterior direction. A lesion that is entirely anterolateral to the vein and located medial to the U line would erroneously be designated as a deep lobe tumour. Anterior to the RV, very little parotid gland tissue is located medial to the facial nerve branches. Therefore, almost every lesion anterolateral to the

vein will be a superficial lobe tumour. In light of the findings from that anatomic study, we conclude that when using the U line, every tumour found to be located completely anterolateral to the RV should also be designated as a superficial lobe tumour.

When all of the lesions had been classified, we checked the surgical report to see whether a superficial or a total parotidectomy had been performed. (For information about the type of tumours, see Table 1.) Afterwards, we tallied the times a tumour was localized correctly by applying the U line and the FN line.

Table 1. Type of tumour for the 28 patients.

Type of tumour	Number of patients
benign mixed tumour	17
Warthin's tumour	5
oncocytoma	1
acinic cell carcinoma	2
myoepithelioma	1
malignant myoepithelioma	1
benign cyst	1

Table 2. Accuracy of assessments with FN line and U line.

	Assessments		
	Correct	Incorrect	Unable to assess
FN line	20	5	3
U line	24	2	2

Results

According to the surgical reports, in 20 cases the position of the tumour required only surgery of the superficial lobe of the parotid gland. Thus in eight (29%) cases, surgery of the deep lobe was required as well. Using the FN line, the position of 20 (71%) of 28 tumours was

correctly predicted, including four (50%) of eight deep lobe tumours; using the U line, the correct prediction was made in 24 (85,7%) out of 28 cases, including six (75%) of eight deep lobe tumours. On three scans it was not possible to draw the FN line. On two scans, it was not possible to draw the U line. The failure to draw these lines may be explained either by the poor quality of the scan or by the fact that the relevant structures were not visible (Table 2). In two cases, the tumour appeared to be lateral to both lines on the scan. However, when performing surgery, the tumour was found to be in both lobes and so these tumours required more extensive surgery than expected. When using the FN line, in two additional cases, a tumour was predicted to be superficial but turned out to be a deep lobe tumour (see Figure 2 and 3). One lesion was predicted to be a deep lobe tumour using the FN line but turned out to be a superficial lobe tumour.

Three tumours were located completely anterolateral to the RV and were tallied as superficial lobe tumours, although located medial to the U line (see Figure 4).

Discussion

The anatomic study mentioned earlier was performed on transverse sections of cadaver heads.[5] In light of our findings, we proposed using an anatomic line (U line) with a course nearly parallel to the intraparotid course of the facial nerve to predict the location of parotid gland tumours on axial MR images and CT scans. The present retrospective study suggests that the U line indeed may be very helpful in clinical practice to determine the position of parotid gland tumours relative to the course of the facial nerve. Only twice (that is, in 8% of the patients) did we incorrectly predict the location of a parotid gland tumour. In five instances either the FN line or the U line could not be drawn due to the poor quality of the scan. Therefore, a prospective study will be initiated to establish the usefulness of the U line in clinical practice.

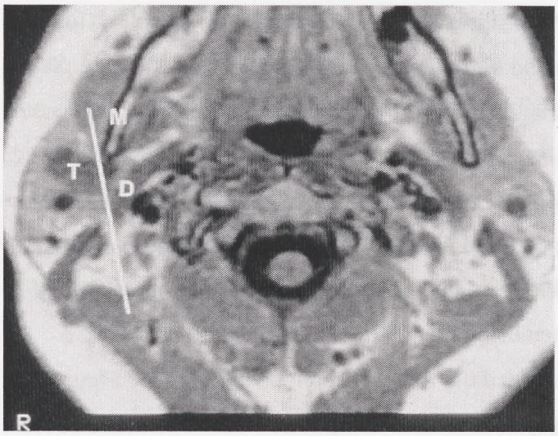

Figure 2. Axial Magnetic Resonance Image of a parotid gland tumour. According to the FN line, this tumour should be superficial. However, at surgery, the tumour was found in the deep lobe. D = digastric muscle, M = mandible, T = tumour.

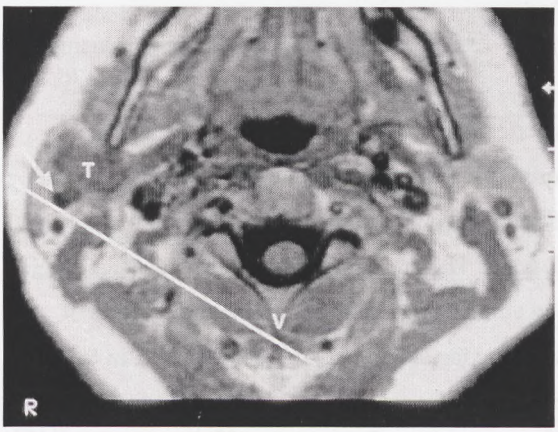

Figure 3. Same patient as in Figure 2. According to the U line, this is a deep lobe tumour. At surgery the tumour was indeed found in the deep lobe. V = vertebra, T = tumour, arrow points to the retromandibular vein.

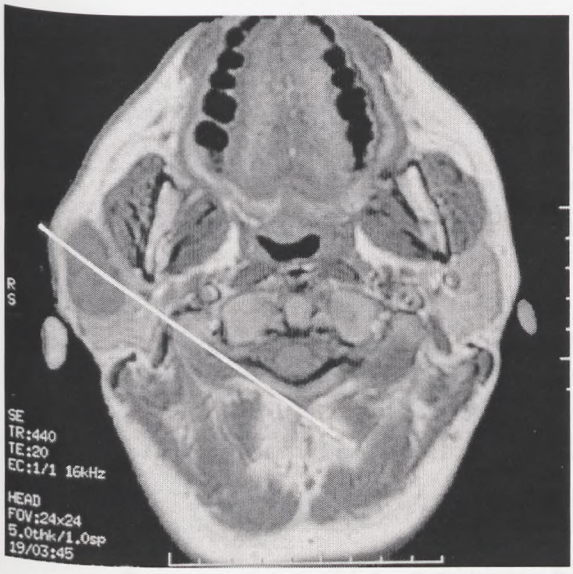

Figure 4. Magnetic Resonance Image of a parotid gland tumour. The U line is drawn on the scan. This tumour is partly medial from the U line. Since it is also totally anterolateral to the retromandibular vein, it was designated as a superficial lobe tumour. At surgery, the tumour was found to be located superficial to the facial nerve.

Acknowledgement

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5

Do MRI and ultrasound add anything to physical examination and fine needle aspiration cytology in the pre-operative work-up of parotid gland tumours?

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Introduction

In the pre-operative work-up of a patient with a parotid gland tumour, two questions need to be addressed in order to inform the patient correctly about the chance of complications and to plan the appropriate surgical procedure. The first question is whether the tumour is benign or malignant; the second one concerns the location of the tumour relative to the facial nerve.

Pre-operative evaluation usually consists of history taking and physical examination (PE), and fine needle aspiration cytology (FNAC). The ability of FNAC to determine the benign or malignant nature is well established, with an accuracy varying from 85 to 97%.[1,2,3,4,5,6] In addition imaging is frequently requested. MRI is the preferred procedure due to its superior soft tissue differentiation.[7] On MRI, signal intensity, heterogeneity, indistinct margins, and invasion of adjacent structures are features which can help to define the nature of a parotid tumour.[1,8,9] However, Freling et al. did not find a statistically significant correlation between both tumour signal intensity and marginal appearance, and the tumour grade/histologic nature.[10] MRI is reported to correctly differentiate between benign and malignant tumours in 80 to 90% of the cases.[1,6,11]
On MRI the facial nerve might be visible as a hypo-intense structure entering the parotid gland.[9,12] But, as it courses through the parotid gland, and especially in the presence of a tumour, it cannot be visualized. Therefore, different authors tried to predict the facial nerve's course by using various anatomic landmarks, lines, and arcs topographically related to it.[13,14,15,16] A line - the facial nerve line (FN line) - connecting the lateral surface of the posterior belly of the digastric muscle with the lateral surface of the cortical bone of the ascending ramus of the mandible indicated tumour location correctly in 88% of the cases.[16] The Utrecht line (U line), connecting the most dorsal point visible of C1 or C2 vertebra to the retromandibular vein (RV), accurately diagnosed tumour location, retrospectively, in 85% of the cases.[17,18]

Ultrasound (US) is frequently requested due to its availability, low cost, and as a practical means of obtaining image-guided FNAC. The reported ability of US to differentiate benign from malignant tumours ranges from 80 to 87%.[19,20] The deep lobe of the parotid gland is not well visualized with US, as it is obscured by the mandible.[8,12] Also with US the facial nerve cannot be visualized. Its course might be deduced from the position of the RV as the nerve is closely associated with this vessel.[8,21]

In our hospitals - the University Medical Centre Utrecht and the Hospital Centre Apeldoorn - clinicians routinely request US, US-guided FNAC, and MRI in patients with a tumour in the parotid gland.
This study prospectively evaluated the additional value of US and MRI to PE and FNAC in the pre-operative work-up of parotid gland tumours in order to investigate the appropriateness of our standard programme of care.

Materials and Methods

Patients

All patients with a suspected parotid gland tumour visiting our hospitals were prospectively enrolled in the study from December 1999 till March 2003. No exclusion criteria were defined.

Symptoms and physical examination

Pain at rest and facial nerve dysfunction were noted. Facial nerve function was classified according to the House-Brackmann (HB) classification.[22] Consistency of the tumour was assessed, and the neck was palpated for lymph nodes. Clinicians judged the tumour as confined to the deep lobe, the superficial lobe, located in both lobes, or unable to localize.

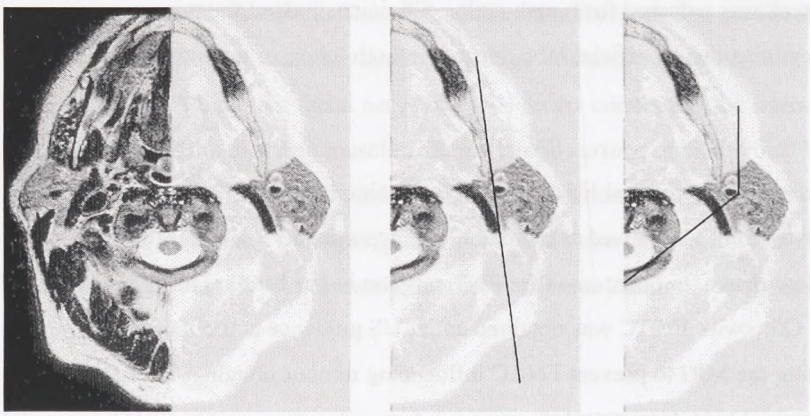
FNAC

In many cases referred to our hospital FNAC had been obtained already. FNAC from a referring hospital was usually reviewed at our pathology department. Sometimes FNAC was repeated under US guidance. In other cases the ENT surgeon in our hospital had already performed FNAC. Otherwise FNAC was obtained under US guidance at the radiology department following the MRI to prevent FNAC influencing tumour imaging. In case of a non-diagnostic sample, FNAC was repeated.

MR imaging

MRI sequences were acquired at 1.5 Tesla, using a quadrature volume neck coil and 512 matrix and the following protocol: axial T1 weighted, T2 weighted, proton density and T2W STIR series were performed with 220 FOV and TE/TR of 17/shortest, 130/4200, 16/1600 and

130/3500 respectively. Coronal T2W STIR with 280 FOV, 130 TE, and 3500 TR. The images were reviewed by an experienced radiologist blinded to the clinical findings. Tumours were defined as intra-glandular, having extra-glandular (including parapharyngeal) extension, or located outside the parotid gland. For each tumour the following imaging features were noted: 1) signal characteristics on T1- and T2-weighted images; 2) homogeneity; 3) presence of cystic areas; 4) regularity of the margin; 5) demarcation from normal parotid tissue; 6) multiplicity; 7) presence of enlarged (>1 cm) lymph nodes; and 8) presumed histological diagnosis (pleomorphic adenoma, Warthin's tumour, malignant, cystic, other benign tumour). The relation of the tumour to the facial nerve was predicted using both the FN line, and the U line (see Figure 1). Tumours totally superficial to a line were determined as located in the superficial lobe. Since the intraparotid course of the facial nerve changes from oblique to anteroposterior beyond the RV, tumours located totally anterolateral to the RV were also predicted to be located in the superficial lobe.[18] Tumours located totally medial to the lines were determined as deep lobe tumours. The remainder were stratified as mostly superficial (estimated more than 50% superficial to a line), about equally in both lobes (divided in about equal parts by a line), or mostly deep (estimated more than 50% deep to a line).



a b c

Figure 1. (a) MR image of the neck at the level of the parotid gland. Ariyoshi's facial nerve (FN) line (b) connecting the lateral surface of the posterior belly of the digastric muscle to the lateral surface of the cortical bone of the ascending ramus of the mandible, and the Utrecht (U) line (c) connecting the most dorsal point visible of C1 or C2 vertebra to the retromandibular vein, are used to indicate the presumed course of the facial nerve.

Ultrasound

US was performed according to a standard protocol by the radiologist assigned to US for that day who was blinded to the PE and MRI results. Tumours were defined as intra-glandular, having extra-glandular (including parapharyngeal) extension, or located outside the parotid gland. For each tumour the following imaging features were noted: 1) echogeneity; 2) homogeneity; 3) presence of cystic areas; 4) regularity of the margin; 5) demarcation from normal parotid tissue; 6) multiplicity; 7) presence of enlarged lymph nodes (> 5 mm short axis, or clustered > 4 mm); 8) hypo- or hyper-vascularity with respect to the surrounding tissue; and 9) presumed histological diagnosis (pleomorphic adenoma, Warthin's tumour, malignant, cystic, other benign tumour).

Tumour location relative to the facial nerve was assessed by means of its relative position to the RV and to the line between mastoid and mandible (MM line) (see Figure 2). A tumour lateral to either the line or the RV was determined as a superficial lobe tumour, a tumour totally medial to either the line or the RV as a deep lobe one. Tumours divided in about equal parts by the MM line, or the sagittal plane through the RV, were judged as being in both lobes equally. Tumours mostly (more than 75%) lateral or medial to the line or the vein were classified as mostly superficial or mostly deep lobe tumours respectively.
In one of the hospitals US was only performed to obtain FNAC and to exclude other diagnosis than parotid gland tumour; therefore, these US examinations were not included in the results.

Standard of reference

The standard of reference as to the nature of the tumour was the pathologist's report concerning the histology.
To obtain a standard of reference for the location of a tumour relative to the facial nerve, the operating surgeons, blinded to the protocol outcome, described the location of a tumour at exploration as follows: totally deep or superficial; mostly (more than 75%) deep or superficial to the facial nerve; or bridging the facial nerve plane. If a branch of the facial nerve was incorporated in the tumour, this tumour was, by definition, not confined to one lobe.

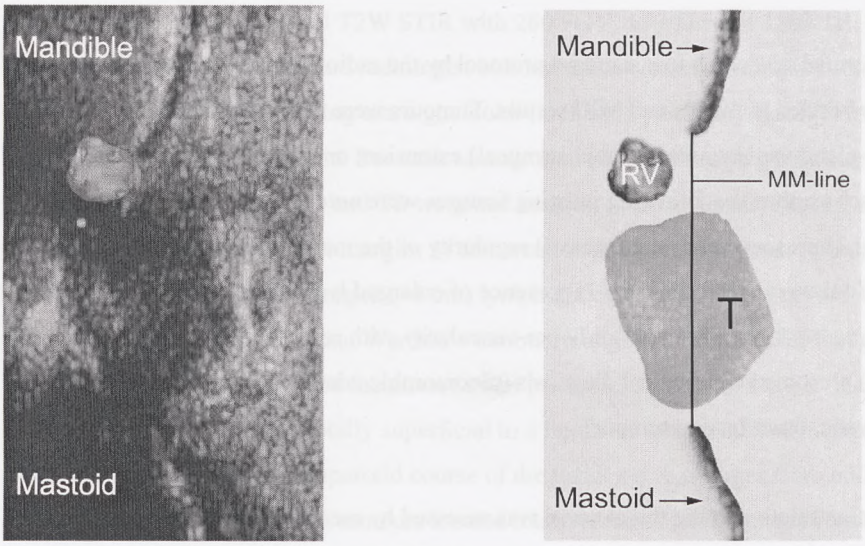


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Figure 2. (a) Image obtained with ultrasound examination of a parotid gland tumour and its location relative to the retromandibular vein and the line between mastoid and mandible (MM). (b) Schematic drawing of image (a) showing the tumour (T), the retromandibular vein (RV), and the MM line.

Results

Patients, tumours, and procedures

A total of 99 patients (48 male, 51 female; age 19-85, mean age 56) were enrolled during the study period. Ninety-seven of these patients had an intra-glandular tumour location, whereas two patients eventually appeared to have a lesion located outside the parotid gland. Seventy-seven patients (78%) in this group had a benign lesion and the majority (55%) of these were pleomorphic adenomas. In 22 patients (22%) the tumours were malignant, including five metastatic lesions. (For tumour classification, see Table 1.) Eighty-two patients underwent parotidectomy (including 57 partial superficial, one superficial, four partial deep, nine partial, six total and four radical parotidectomies, and one trans-oral resection).

Table 1. Tumour classification in 99 cases.

	Total	(histology + cytology only)
Benign tumours (66)		
pleomorphic adenoma	42	(41 + 1)
Warthin's tumour	18	(14 + 4)
other	6	
Malignant tumours (22)		
primary parotid gland tumours	16	
MALT-lymphoma	1	
metastatic malignancy	5	
Rest group (11)		
cystic	3	
lymph node	3	(1 + 2)
chronic inflammation	1	
not operated	4	

Symptoms and physical examination

Reports of PE were collected in 94 patients. Pain was experienced in 10 patients and one of them experienced spontaneous muscle contractions. Of these 10 patients, five (including the one with spontaneous muscle contractions) had a malignant tumour. Five lesions were judged as more solid than usual on palpation, and all five were malignant; however, only 23% of the malignant tumours had this characteristic on PE.

All primary benign cases had facial nerve function described as HB grade I (normal function). Six out of 22 patients with a malignant tumour (27%), and one with a recurrence after surgery for a benign tumour, had a HB classification varying from II to VI (paralysis).

On palpation 68 tumours were judged to be located in the superficial lobe (see Table 2). This was correct in 55 patients, yielding a Positive Predictive Value (PPV) for superficial location of 0.81. All tumours judged to be in both lobes or in the deep lobe, as well as the uncertain cases, were indeed not confined to the superficial lobe only.

FNAC and histology

FNAC was obtained in 88 patients. Twenty-one cytology reports were available from referring hospitals, FNAC was obtained in 26 cases by the ENT surgeon in our hospital prior

to imaging, and 41 patients underwent US-guided FNAC. In 32 cases pleomorphic adenoma was the cytological diagnosis. Compared to histology this was correct in 31 cases (see Table 2). The tumour incorrectly classified at FNAC as pleomorphic adenoma was classified as a basal cell adenoma at histology. The cytological classification was Warthin's tumour 18 times, which was confirmed at histology in all 14 operated cases. All FNAC reports from our hospitals correctly classified the tumours as benign or malignant. One FNAC specimen, from a referring hospital, had been classified elsewhere as a possibly malignant tumour. Repeated FNAC at our hospital did not show signs of malignancy, and the tumour was classified as non-malignant, not specified. At histology a myoepithelioma was found.

Table 2. Location assessed by palpation at the outpatient clinic versus the definite location as judged by the surgeon for 81 parotidectomies.

	Definite					
Palpation	superficial	mostly superficial	both	mostly deep	deep	Total
superficial	55	5	5	1	2	68
both			4		2	6
uncertain			2		1	3
deep			2		2	4

Positive Predictive Value of palpation for:
superficial location of a tumour: 55/68 = 0.81
simple operation (superficial and both): 69/74 = 0.93
extended operation (uncertain and deep): 3/7 = 0.43

MRI

Eighty-nine out of 99 patients underwent MRI according to the protocol. Definite histology was difficult to predict on MR images; presumed diagnosis was correctly predicted according to the five categories in 63 out of 85 cases (74%). Malignant nature of the tumour versus all benign lesions (i.e. the other four groups) was correctly predicted in 87% of the cases (see Table 3). Using all imaging features, the PPV for malignancy was 0.7. The highest PPV for malignancy of the individual imaging characteristics was 0.48 for incomplete demarcation

from normal parotid gland tissue, whereas the highest negative predictive value (NPV) to exclude malignancy was 0.92 for regular margin and 0.88 for homogeneous tumours. The other individual characteristics had a PPV for malignancy varying between 0.45 (parapharyngeal extension) and 0.16 (intraglandular location).

Table 3. Presumed diagnosis on MRI scans correlated to the definite histology.

	Definite					
Presumed	pleom. adenoma*	malignant	Warthin's	cystic	benign, other	Total
pleom. adenoma*	33	1	2		1	37
malignant	2	16	2		3	23
Warthin's			7	1	1	9
cystic		1				1
benign, other	2	2	4		7	15

* (pleom. adenoma = pleomorphic adenoma)

Positive Predictive Value of MRI for:
pleomorphic adenoma: 33/37 = 0.89
malignancy: 16/23 = 0.7
Correct differentiation between benign and malignant in 74 cases (87%).

The FN line and the U line could be drawn at the level of the tumour on 79 (89%) and 85 (96%) scans respectively. In the remaining cases one or both of the landmarks necessary for drawing the line was not visible at tumour level. Using the FN line, 42 out of the 50 tumours predicted to be in the superficial lobe were indeed found to be as superficial during the operation, yielding a PPV for superficial location of 0.84. The U line provided a correct prediction in 46 cases, with a PPV for superficial location of 0.88. The tumours entirely located in the deep lobe at surgery were incorrectly localized in seven out of eight cases using both lines. Of these tumours, almost half were assessed as being located superficial, or mostly superficial to the facial nerve (see Table 4).

Ultrasound

Sixty-one out of 99 patients had US performed in the main institute. Of these, 47 were evaluated according to all criteria of our protocol. Most tumours were assessed as pleomorphic adenoma; however, this prediction was correct in 50% of cases only. The pathology was correctly predicted according to the five categories in 20 out of 47 cases (43%). If only the benign or malignant nature was predicted, this was done correctly in 31 of 46 cases (67%) (see Table 5).

Table 4. Localization on MRI using the FN line or the U line versus the definite location according to the surgical report.

	Definite					
FN line	superficial	mostly superficial	both	mostly deep	deep	Total
superficial	42	4	3		1	50
mostly superficial	6			1	2	9
both			4		1	5
mostly deep					3	3
deep					1	1
no FN line	3	1	2	1		7

	Definite					
U line	superficial	mostly superficial	both	mostly deep	deep	Total
superficial	46	3	2	1		52
mostly superficial	4	1	1	1	4	11
both			5		2	7
mostly deep			1		1	2
deep			1		1	2
no U line	1					1

Positive Predictive Value on MRI using the FN line for:
superficial lobe tumour: 42/50 = 0.84
simple operation (superficial, mostly superficial, both): 59/64 = 0.92
extended operation (deep, mostly deep): 4/4 = 1

Positive Predictive Value on MRI using the U line for:
superficial lobe tumour: 46/52 = 0.88
simple operation (superficial, mostly superficial, both): 62/70 = 0.89
extended operation (deep, mostly deep): 2/4 = 0.5

Using all imaging features, US demonstrated a PPV for malignancy of 0.3. The individual imaging characteristics had a low PPV for malignancy, ranging from 0.5 (presence of enlarged lymph nodes) to 0.2. The highest NPV to exclude malignancy was for homogeneity (NPV 0.93).

On US the RV could be identified at tumour level in 37 cases (79%) and the MM line in 31 cases (66%). Using the relation of the tumour to either the RV or the MM line, superficial location was adequately predicted in 12 out of 17 cases (71%) and seven out of 10 cases (70%) respectively (see Table 6).

Table 5. Presumed diagnosis on ultrasound examination versus the pathology report.

	Histology					
Ultrasound	pleom. adenoma*	malignant	Warthin's	cystic	benign, other	Total
pleom.adenoma*	15	6	5	2	2	30
malignant	4	3	2		1	10
Warthin's	1	2	1		1	5
cystic						
benign, other					1	1

* (pleom. adenoma = pleomorphic adenoma)

Positive Predictive Value of US for:
pleomorphic adenoma: 15/30 = 0.5
malignancy 3/10 = 0.3
Correct differentiation between benign and malignant in 31 cases (67%).

Simple versus extensive surgery

For patient counselling and planning of surgery, discrimination is essential between tumours that are relatively simple to resect with a lower chance of post-operative facial nerve damage, and tumours that require a more extensive operation with a corresponding higher risk of facial nerve damage. To that purpose, we divided our patients in two groups. The first group comprised patients with (mostly) superficial lobe tumours or tumours bridging the facial nerve plane between its branches - located on both sides equally (these are in our opinion still relatively easy to resect by simply extending a partial superficial parotidectomy). The second

comprised patients with a (mostly) deep lobe tumour. The correct prediction after assignment to one of these groups would be as follows. The PPV for a relatively easy operation would be 0.93 on PE, and 0.92 and 0.89 on MRI (using the FN line and the U line respectively), and 0.88 and 0.9 on US (using the RV and the MM line respectively).

On palpation the PPV for more difficult operations was only 0.43, whereas both MRI (using the FN line) and US (using the MM line) predicted more difficult operations with a PPV of 1. However, the US group consisted of only two cases for the MM line.

Table 6. Localization on ultrasound using the retromandibular vein (RV) or the MM line versus the definite location according to the surgical report.

	Definite					
RV	superficial	mostly superficial	both	mostly deep	deep	Total
superficial	12	2	1		2	17
mostly superficial	3	1				4
both	2		2		1	5
mostly deep			1		1	2
deep						
no RV	5	1	1	1	1	9

	Definite					
MM	superficial	mostly superficial	both	mostly deep	deep	Total
superficial	7	2			1	10
mostly superficial	4	1				5
both	4		1		1	6
mostly deep					1	1
deep					1	1
no MM line	7	1	4	1	1	14

Positive Predictive Value on US using the RV for:
superficial lobe tumour: 12/17 = 0.71
simple operation (superficial, mostly superficial, both): 23/26 = 0.88
extended operation (deep, mostly deep): 1/2 = 0.5

Positive Predictive Value on US using the MM line for:
superficial lobe tumour: 7/10 = 0.7
simple operation (superficial, mostly superficial, both): 19/21 = 0.9
extended operation (deep, mostly deep): 2/2 = 1

Discussion

In this clinical evaluation, all patients with a suspected parotid gland tumour, including the malignant and the previously operated cases, were prospectively included. Not all patients, though, underwent all procedures of our protocol. Some patients had only one of the imaging modalities performed for the following reasons: MRI or a Computed Tomography scan had already been performed in the referring hospital and no additional imaging was judged to be necessary by the attending physician (n = 7); histology or a cytological classification was already available at the first consultation (n = 17); reluctance to undergo MRI due to claustrophobia (n = 1); other reasons not specified (n = 5). Consequently, it was not possible to analyse all patients with our total protocol. The result is a heterogeneous population in which not all patients received the same diagnostic evaluation. We think that this is inherent to working in a tertiary care centre, and it reflects the normal clinical situation. Furthermore, the diagnostic tools were separately compared to the gold standard. Therefore, we think that the main results would not have been much different if all diagnostic tests had been performed for all patients.

Recently, Fee and Tran stated in an editorial that MRI and US are seldom necessary in the work-up of a patient with a parotid mass, because these tests do not provide 100% accuracy, and do not show the location of the facial nerve relative to the tumour.[23] Our clinical data support their opinion.

Differentiation between benign and malignant tumours

Facial nerve paresis and a solid tumour consistency at PE were both highly indicative of malignancy. However, these findings were only present in a minority of patients with a malignant tumour, so the usefulness of these findings is rather limited.

FNAC proved an excellent indicator for malignancy with a 100% correct discrimination between benign and malignant tumours. This is in accordance with the literature, which shows a high accuracy ranging from 85 to 97% in differentiating benign from malignant tumours. Of course, in order to arrive at a correct cytological diagnosis an experienced cytopathologist must examine the cytological material.

On MRI, 20% of all malignancies were not recognized as such, and none of the individual imaging characteristics was reliable in differentiating between benign and malignant tumours. Our accuracy in differentiating benign from malignant tumours, with correct prediction in 88% of the patients, is in line with the 80 to 90% reported in literature.

Using all imaging features, US demonstrated a PPV for malignancy of 0.3. A correct differentiation between benign and malignant tumours was made in 67% of the cases. This is a poor result compared to other studies with a reported accuracy as high as 80 to 87%. This difference might be explained by the fact that in our study comparatively more malignant tumours were included, due to the tertiary referral function of one of the hospitals. Furthermore, in our study US was not performed by just one or two radiologists specialized in US of the parotid gland but by the radiologist assigned to US for the day. These findings concur with Lamont et al., who failed to find reliable diagnostic features.[24]
On the basis of this study we conclude that FNAC is the only accurate investigation for classifying a parotid gland tumour as benign or malignant. Therefore, we advocate performing FNAC in all cases. In cases of easily palpable lesions, this can be performed without US.

Location relative to the facial nerve

We conclude that PE predicts the superficial location of a tumour, and especially for the relatively simple operations, as adequately as MRI and US. As our imaging results for MRI are as good as the results mentioned in the literature, we think that the additional value of these imaging techniques compared to PE is at this moment not high enough to warrant MRI or US in all patients with a parotid gland tumour.

Practical implications

The practical implications of our findings can be summarized as follows. In all patients with a parotid tumour, FNAC should be performed by a person with experience in the technique of aspirations, which will clarify the benign or malignant nature of the tumour correctly in most cases. If a benign tumour is judged to be superficial on PE, the patient can proceed to surgery without US or MRI, obviating the need for imaging in the majority of patients with a parotid gland tumour. (About 80% of parotid gland tumours are benign; 85% of the parotid gland tissue is located superficial to the facial nerve, so the majority of tumours will also be located in the superficial lobe.)
The limitation of PE, assessing 'simple to remove' tumours incorrectly in 7% of the cases, cannot be compensated with MRI or US, which misclassified 8 and 12% of the 'simple to remove' tumours. More than half of the deep lobe tumours were not recognized as such. This is in accordance with El-Hakim et al., who stated that almost half of the deep lobe lesions can be mislocated.[25] This outcome nullifies the reason to perform routine imaging for locating a parotid gland tumour.

However, if a benign tumour is clinically judged as bridging the facial nerve plane (requiring an extended PSP) or as located in the deep lobe (requiring extensive surgery), MRI might help to differentiate between these locations. On PE the PPV for more difficult operations is 0.43, whereas the PPV for more difficult operations on MRI is 1.0 using the FN line.
If a malignant tumour is assessed on PE as confined to the superficial lobe, the surgeon will still try to spare the facial nerve by performing a (partial) superficial parotidectomy. In these patients MRI is often requested to identify signs of local infiltration into adjacent structures, and it can help to detect lymph node metastasis. However, we have no data to support the usefulness of MRI for this purpose. If a malignant tumour is clinically judged to extend beyond, or arise deep to the facial nerve plane, the chance of sparing the facial nerve is reduced. MRI is still required to identify infiltration into the parapharyngeal or carotid spaces. In our opinion, the role of US is limited to detection of enlarged lymph nodes and guidance of FNAC for both the tumour and the lymph node metastasis.

Although the relatively disappointing performance of MRI and US is hardly novel, we think that this article can contribute to a change in the traditional work-up of patients with a parotid gland tumour, because in many hospitals MRI or US are still routinely requested.

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6

Morbidity of parotid gland surgery, results one year post-operative

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Introduction

Parotid gland tumours are usually (in 80% of the cases) benign. About 85% of the parotid gland is located lateral to the facial nerve – i.e., in the superficial lobe – so most of the tumours are superficial to the facial nerve. Thus, a partial superficial parotidectomy is now the treatment of choice in most cases. Total or superficial parotidectomies are thought to be unnecessary for preventing recurrence.[1,2]
Besides recurrence of tumour, the main complications of parotid gland surgery reported in the literature are facial nerve damage, salivary fistula, and Frey's syndrome. The incidence of facial nerve paresis/paralysis is as high as 30 to 65% for transient weakness and 3 to 6% for permanent dysfunction.[3] The incidence of Frey's syndrome varies widely in the literature, depending on the surgical techniques, the type of surgery, and whether or not an objective test was performed to diagnose the gustatory sweating. Some physicians report a high incidence (of 85 to100%), while others indicate that only a small proportion (4%) of their patients end up with this problem.[4,5,6] Salivary fistula are mentioned in less than 2% of the cases.[1]

However, these complications are less frequent today, probably because of better surgical techniques and less extensive surgery. O'Brien reported only 0.8% re-growth of tumour and 2.5% permanent facial weakness.[1] By using an interposing flap made of the superficial musculo-aponeurotic system (SMAS), Bonanno and Casson as well as Casler and Conley were able to prevent Frey's syndrome completely. They had no clinical evidence of gustatory sweating in their groups of patients.[7,8] Their SMAS flap was described as follows. Following removal of the tumour, an anterior cuff of tissue can be demonstrated, which is composed of the remaining SMAS and the parotidomasseteric fascia or gland capsule. This tissue is brought posteriorly and is sutured to the anterior border of the sternocleidomastoid muscle.[7]

Consequently, attention is now focused on problems that occur more frequently. These include anaesthesia/hypoaesthesia and allodynia/dysaesthesia of the area innervated by the great auricular nerve (GAN), as shown in Figure 1, but also scarring and deformity in the region.[2,9,10,11,12,13]

In order to study morbidity after parotid gland surgery, we prospectively evaluated the patients who had been operated on in our hospitals over the past three years.

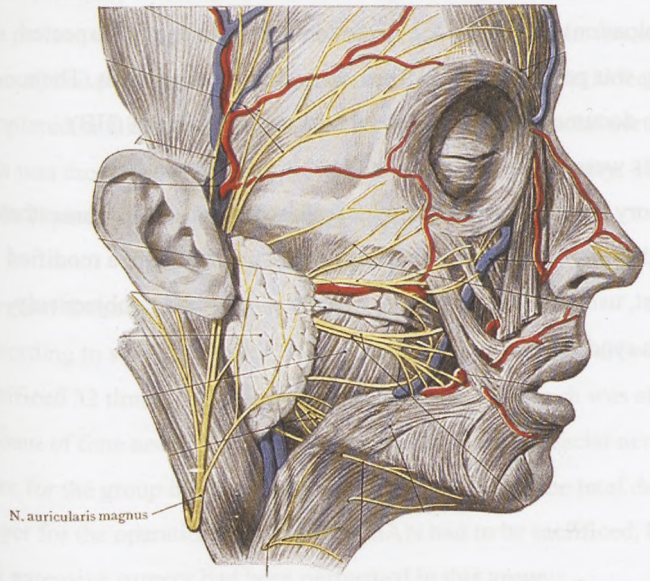

Figure 1. The great auricular nerve and its course over the sternocleidomastoid muscle in the direction of the auricle. It divides into posterior and anterior branches. The anterior branches are located superficial to the parotid gland, and some branches might enter it. (Original source of drawing unknown)

Materials and Methods

Patients seen from December 1999 till March 2003 at the ENT department of our hospitals for a parotid gland tumour were prospectively included in this study. No exclusion criteria were defined. Pre-operatively, the medical history was noted. At surgery, the head-and-neck surgeon was asked to complete a questionnaire regarding the operation. The questions concern the landmarks used for facial nerve identification, preservation of the posterior branch of the GAN, the amount of time it took to identify the main trunk of the facial nerve, as well as the duration of the operation, usage of a microscope, and whether the facial nerve could be stimulated after tumour removal (to verify anatomic integrity of the nerve for predicting total recovery). Furthermore, the surgeons were asked to determine the location of a tumour relative to the facial nerve. Finally, it was noted whether or not a modified SMAS interposition was used to prevent Frey's syndrome, as described above.

If possible, the patients were evaluated after surgery at regular intervals (1 week, 1 month, 3 months, 6 months, and 1 year). At the post-operative consultation, the patients were examined (i.e., by history-taking and palpation) for recurrence of the tumour. In case of a suspected recurrence, FNAC or imaging was performed to confirm or exclude this diagnosis. Their facial nerve function was also documented according to the House-Brackmann (HB) classification.[14] The patients were asked if they had noticed gustatory sweating. Furthermore, the area of sensory deficit (anaesthesia/hypoaesthesia/dysaesthesia/paraesthesia) was measured. Follow-up ended after at least one year. At the last consultation, a modified Minor's starch-iodine (SI) test, using flavoured sweets, was also performed to objectively discern the presence of Frey's syndrome.[3]

Results

The group consisted of 99 patients (48 male, 51 female; age 19-85, mean age 56). The tumours were benign in 77 cases and malignant in 22 cases. Of the whole group, 81 patients underwent parotidectomy and one had a transoral resection. Any malignant tumours remaining were irradiated. The remainder of the lesions that were probably benign were not operated on because of various contra-indications: e.g., age; unrelated disease; lesion too small; or the expectation that the swelling was only a lymph node. After surgery, 61 completed questionnaires were returned by the surgeons. One week after the operation, their 61 patients were evaluated. One month after surgery, only 37 were documented. At three months post-operatively, 41 patients were evaluated, at six months 40, and at one year after surgery 45 patients were evaluated. Most of the patients 'lost to follow-up' were referred back to their initial referring physician. This group did not differ from those followed up at our clinic.

Facial nerve function

At one week post-operatively, 61 of the patients visited the outpatient clinic. A haematoma had formed in two of these patients; in one, the wound had become infected. Facial nerve dysfunction was noticed 26 times. This was severe (HB grade IV, V, and VI) in 15 cases and

mild (HB grade II, III) in 11. All patients with a benign tumour visiting our hospitals for primary surgery had a normal functioning facial nerve (HB I) six months after the operation. One patient who was referred for a recurrent benign tumour (recurrence of a Warthin's tumour) had permanent severe facial nerve paresis. The parotidectomy could not be completed in this patient because the main trunk of the facial nerve could not be identified. This was the result of scarring/fibrosis due to previous surgery. This patient already had a HB grade II paresis when he first visited our hospital.

Surgical technique

According to surgical reports, the posterior branch of the GAN was spared 29 times and sacrificed 32 times. (On two occasions, the anterior branch was also preserved.) The mean amount of time needed to identify the main trunk of the facial nerve was less than 10 minutes more for the group in which the GAN was preserved. The total duration of the procedure was longer for the operations in which the GAN had to be sacrificed, but more neck dissections and extensive surgery had been performed in this group.

In all primary benign cases, the facial nerve could be stimulated to verify integrity. In the patient with the recurrent Warthin's tumour, the facial nerve was not identified and could thus not be stimulated. A modified SMAS interposition was used in 32 cases.

Recurrence

The tumours came back in four patients. In one, an acinic cell carcinoma was found in the incision scar from the previous operation. The pathologist's report on the first excision documented a radical tumour removal. Therefore, this patient was not irradiated post-operatively after the first operation. In one patient, metastasis of a renal tumour had not been removed radically on the first occasion and recurred after one year. Though this patient had been offered post-operative irradiation, she had refused this therapy. Two patients had recurrences of their pleomorphic adenomas. Both had previously been operated on elsewhere for the same tumour.

One patient died due to distant metastasis of a pleomorphic adenoma. She too had been operated on before coming to our institute. Although metastasis of a pleomorphic adenoma is very rare, it has been described in the literature.[15,16,17] Another patient died of brain metastasis from a malignant parotid gland tumour.

Frey's syndrome

In four cases, the SI test showed gustatory sweating post-operatively. In two of these, this occurred in a small area (less than 1 cm^2 in size). Both of these patients were operated on for malignancy. Neither one had noticed any gustatory sweating. The other two patients suffering from Frey's syndrome were already familiar with it when first visiting our department. By then, they had already developed it due to previous operations elsewhere. In all four of these cases, no SMAS interposition had been applied.

One additional patient complained of gustatory sweating and crocodile tears, but the SI test did not show any colouring after more than 10 minutes with lemon sweets. The remainder of our patients had no symptoms of Frey's syndrome.

Hypo-/hyperaesthesia

One week post-operatively, the area of disturbed sensation was about equal for the group of patients who had the GAN preserved and the ones who had it sacrificed. Measurement showed a mean diameter of the area of 7.8 and 7.9 cm respectively (see Table 1). However, for the group whose posterior branch had been spared, there was a slow decline of the mean distance: from 7.3 cm at one month to 7 cm at three months, 6.8 cm at six months, and 5.8 cm after one year. While the group in whom the branch had been sacrificed initially showed a similar decline (to 7.7 cm at one month and 7 cm at three months), the area increased again to 7.4 cm after six months, ending at a mean of 8.3 cm after 12 months. This expansion was mainly due to hyperaesthesia and allodynia of the operated area.

If we focus on the median diameter of the area, a similar difference between these groups is noted. After one year, the median for the group in whom the nerve had been preserved was 4 cm; for the group in whom it had been sacrificed, the median was 8.4 cm. The largest areas of changed sensation were found in patients who had undergone surgery for malignant tumours and had been irradiated as well as in patients who had been operated on for recurrences. Leaving out the two extremes of both groups, the median diameter was again 4 cm and 7.2 cm, respectively.

Subjectively, patients complained mainly of numbness of the auricle. Furthermore, 14 patients had severe dysaesthesia. In five of these 14 cases, the posterior branch had been spared. Two of the other nine patients had a neuroma of the GAN. One of them even had to be operated on twice for neuroma excision.

Table 1. Mean area of sensory deficit (cm) in the group of patients with the great auricular nerve sacrificed (A) and in the group of patients with the nerve spared (B) during one year post-operatively.

	1 week	1 month	3 months	6 months	1 year
A	7.9	7.7	7	7.4	8.3
B	7.8	7.3	7	6.8	5.8

Discussion

Not all of the patients could be followed up. Nonetheless, in our opinion, the group tested at one year (n = 45) is large enough to support our conclusions. It is also comparable with the size of groups in other studies discussed in the literature. Furthermore, this group does not differ from the group of patients 'lost to follow-up' with regard to age, sex, and tumour characteristics.

The recurrence of tumour and permanent facial nerve paresis/paralysis are surgical complications that can now be avoided in most primary surgical procedures by using the right technique but also by applying the correct strategy (a proper diagnostic work-up, the right surgical landmarks, magnification, stimulation of the nerve during surgery). In this study, we did not see recurrences or permanent paralysis in our primary-operated patients whose tumours were benign. One might argue that this is because our follow-up time is short, since pleomorphic adenoma is known to recur even after more than five years. At our hospital, none of our primary-operated pleomorphic adenoma patients have undergone surgery for a recurrence for several years now. Furthermore, none of the patients in our study group have returned to our clinic for recurrent disease.

Therefore, more attention is being directed towards other complications and permanent morbidity. A SMAS flap interposition can lower the incidence of Frey's syndrome drastically. In our group of primary operated patients, only one complained of Frey's syndrome (but his SI test was negative), and two had a very small dark staining area when tested (though they had no complaints). Two patients who had been operated on for recurrences – having symptoms of Frey's syndrome even before surgery in our hospital – also had positive results

on the SI test. None of the four patients who tested positive nor the one complaining of Frey's syndrome had a SMAS flap. Consequently, we advise using such flaps in all patients if possible.

In light of the sensory deficit remaining post-operatively, the preservation of the GAN warrants more attention, in our opinion. This is not a time-consuming procedure. We, like others, did not need more than 10 minutes of surgery time to preserve the nerve.[10,13] Some authors found that the impact on the patients' quality of life is not significantly affected by GAN sacrifice. Indeed, 90% of the patients in one study reported no interference with their daily activities.[12] In our group, however, 14 patients (32%) complained of severe dysaesthesia with a high impact on their quality of life. Two of these patients needed surgical intervention for neuroma formation. Another young lady did not want to go out dancing with her friends because she was afraid someone would accidentally touch the area, provoking an 'electric shock' sensation. Complications arising after division of the great auricular nerve have been described by others as well.[18] The remainder of patients had allodynia when washing and shaving. When the GAN had been preserved, the mean diameter of the area with changed sensory neural function decreased by more than 2.5 cm.

In this study, we were particularly interested in the effects of saving the posterior branch of the nerve. In the future, we will also consider the effects of saving the more anterior branches. Furthermore, if the location of the tumour makes it necessary to sacrifice a branch, it will also be necessary to prevent dysaesthesia and neuroma formation. In this study, no procedures were performed to prevent these complications. But in our opinion, from now on, the proximal end of a sacrificed nerve should be sutured with a permanent suture and/or be electro-coagulated to prevent sprouting. Moreover implantation into the sternocleidomastoid muscle might be also be helpful. Hopefully, this would lower the morbidity of parotid gland surgery even more.[19,20]

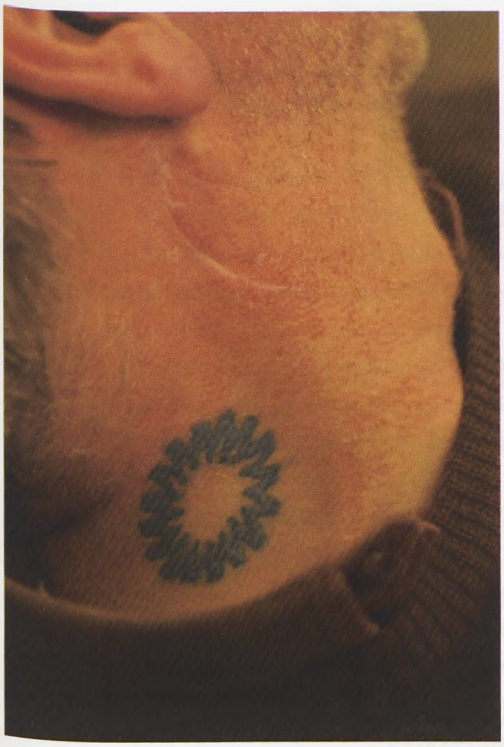

Figure 2. A patient who felt so lucky one year post-operatively for not having had a recurrence, facial nerve paresis, or Frey's syndrome that he had the former emblem of the University Hospital Centre tattooed on the right side of his neck. The scar of the 'lazy-S' incision is still visible.

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7

Prevention of Frey's syndrome in parotid gland surgery

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Introduction

Frey's syndrome is a rather common sequel of parotid surgery or trauma to this region. It was first described by Frey in a patient with a bullet injury to the parotid gland.[1,2] The condition was initially named the 'auriculotemporal syndrome'. It is also known as gustatory sweating. The typical features occur during mastication and include sweating and erythema of the skin in front of the ear and in the region of the angle of the mandible.[3,4,5] Its incidence varies from 10% spontaneously mentioned to 30% admitted on specific questioning and 96% demonstrated with starch-iodine (SI) testing (Minor's test).[3,4,5] The syndrome usually presents itself six weeks to several months after parotid gland surgery, but presentation as late as five years after surgery has been reported too.[6] Although the symptoms are usually mild, in some cases they can cause social impairment, ranging from the need for regular mopping to being virtually house-bound.[6]

The postulated aetiology is an aberrant regeneration of the sectioned parasympathetic fibres, which, after losing their parotid targets, regenerate to innervate the vessels and sweat glands of the overlying skin.[6,7] This involves injury to the auriculotemporal nerve, since postganglionic parasympathetic secrotomotor fibres to the glandula parotidea run within this nerve. This theory was first advanced by Ford and Woodhall in 1938.[3,4,8] The auriculotemporal nerve is a branch of the mandibular nerve. Branching from the posterior surface of the mandibular nerve, it passes backward and slightly downward on the surface of the external pterygoid muscle. This nerve passes on the medial side of the mandible. Then it courses behind the mandible. Next, it enters the deep lobe of the parotid gland. Finally, the nerve courses in front of the ear across the zygomatic arch. In this region, anterior to the tragus, the order of structures from the rear forward is usually auriculotemporal nerve, superficial temporal vessels, and temporal branch of the facial nerve.[9] The communications between the auriculotemporal nerve and the facial nerve have been described elsewhere (see Figure 1).

The incidence of Frey's syndrome differs among the various surgeons reporting it.[10] According to their reports, it occurs more frequently following total parotidectomy than after partial parotidectomy, and it is less common in patients following partial superficial than following superficial parotidectomy.[6] The incidence of Frey's syndrome is also higher following surgery for recurrent parotid tumours.[6]

So far, many different surgical procedures have been applied in an attempt to reduce the incidence of Frey's syndrome and to control the symptoms. The incidence of Frey's syndrome might be reduced by using a thicker skin flap, achieved by scissors dissection.[10] Prophylactic surgical procedures make use of interpositions, either with autografts – of the sternocleidomastoid muscle, the temporoparietal fascial flap, the fascia lata – or with artificial grafts between the parotid bed and the overlying skin.[7,11,12,13] Exceptionally good results have been achieved when the superficial musculo-aponeurotic system (SMAS) is used as an interposing flap. This is said to prevent all gustatory sweating.[5,11]

The literature does not devote much attention to preventing damage to the auriculotemporal nerve as a modality to lower the incidence of Frey's syndrome. Our own clinical observations suggest that Frey's syndrome is rare even without preventive surgical techniques. Therefore, we evaluated the occurrence of Frey's syndrome in our patients who had been operated on for parotid gland tumours. Furthermore, we wanted to study Frey's syndrome again in light of the surgical anatomy.

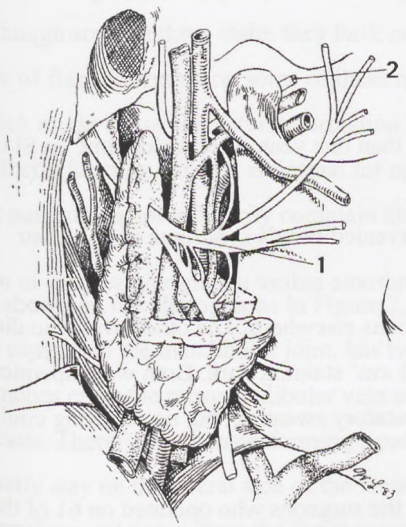

Figure 1 Parotid gland region showing the n. auriculotemporalis and its communicating branches to the n. facialis. 1 = n. facialis, 2 = n. auriculotemporalis.

Materials and Methods

Over the past three years, 81 patients underwent a parotidectomy at our hospitals. Of these operations, 57 were partial superficial, one superficial, four partial deep, nine partial, six total, and four radical parotidectomies for both benign (n = 64) and malignant tumours (n = 17).

When performing a parotidectomy, we use the 'lazy-S' incision. We follow the tragus deep in the direction of the facial nerve. Then the facial nerve is identified, usually with the help of a microscope. The preparation of the skin flap and the liberation of the facial nerve are done by blunt dissection using scissors. At the final stage of the operation, we routinely perform a modified SMAS interposition, described as follows by Casler and Conley. Following removal of the tumour, an anterior cuff of tissue can be demonstrated which is composed of the remaining SMAS and the parotidomasseteric fascia or gland capsule. This tissue is brought posteriorly and sutured to the anterior border of the sternocleidomastoid muscle.[11,14]

Results

Of the 81 patients, 45 could be followed up for more than one year, after which time an SI test was performed.

A modified Minor's test administered to this group revealed Frey's syndrome in only four patients. Two of these patients already had Frey's syndrome before undergoing surgery in our hospital; their symptoms were due to previous operations elsewhere. The other two, who did not have clinical symptoms, had an area of less than 1 cm^2 staining dark. Both were operated on for malignancy. Another patient complained of gustatory sweating, but no sweating could be identified by the SI test.

In our group, according to questionnaires filled in by the surgeons who operated on 61 of the patients, a modified SMAS interposition was used in 32 patients (so in 29 it was not). All five patients mentioned above were in the group of patients who did not have a SMAS interposition.

Discussion

An SI test was performed after more than one year in only 45 cases. Nonetheless, we think that the results can be generalized to the group of 81 patients. Although Frey's syndrome can occur as late as five years post-operatively, we think that most of the patients who are likely to develop gustatory sweating would have been diagnosed within one year, according to the literature.[6,7,15] At the time of the SI test, the patients were informed about Frey's syndrome and offered treatment if the symptoms were to arise in the future. So, it is reasonable to assume that patients with Frey's syndrome symptoms would have returned to our clinic for examination. Till now, however, none of our patients have returned for diagnostics or treatment. Also, our group is large enough to allow comparison with the outcomes of other studies.

Because an interposition might interfere with post-operative follow-up, there are situations where the use of an interposition is not recommended. Specifically, it should not be used in revision surgery, intra-operative tumour spillage, or procedures for malignant tumours. Although some authors claim they have no problem detecting recurrences, we never use this type of flap. Furthermore, some of these methods require extra operating time and dissection which might cause haematoma formation.[13,16] On the other hand, flaps might also serve an aesthetic function, since it is normal for operations of this kind to leave a volume deficit. But our patients do not ordinarily complain about the loss of volume.

As shown on the photographs in Figure 2, the auriculotemporal nerve, which travels behind the capsule of the mandibular joint, has two branches that fuse with the facial nerve. These branches cross the retromandibular vein and external carotid artery on the medial side of these vessels. Therefore, when performing a partial superficial parotidectomy, the surgeon will usually stay on the lateral side of the facial nerve (dissecting the tumour with a margin of normal parotid tissue from the facial nerve branches). By staying lateral to the nerve, the surgeon will consequently stay superficial to the retromandibular vein and thus preserve the auriculotemporal nerve branches (see Figure 2, 3, and 4).

If the pre-auricular incision is made not too far cranial and not too deep in that direction, a relatively large branch of the auriculotemporal nerve will be spared. This will probably be just

a cutaneous branch, not carrying parasympathetic fibres (and thus not transporting the fibres responsible for Frey's syndrome). Nevertheless, we usually try to keep our incision from going beyond the cranial border of the tragus. In this way, and using blunt dissection, little damage to the auriculotemporal nerve's cutaneous branch is expected. Some authors describe the anatomy of the auriculotemporal nerve in relation to parotid gland surgery. Yet to our knowledge, there are no reports describing techniques to prevent damage to this nerve.[17] In particular, no description was found in the literature concerning the parasympathetic or sympathetic function of the cutaneous branch of the nerve. This might be an interesting field for future studies.

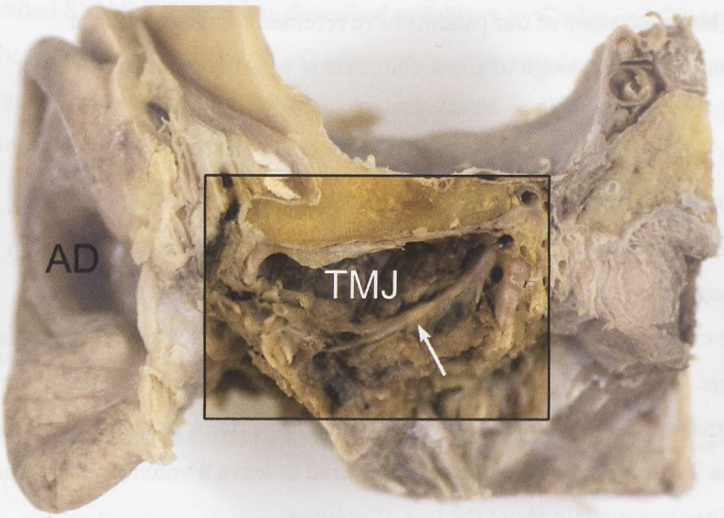

Figure 2. Photograph of the right temporal bone (AD = auricula dextra). The mandible has been removed. Area of interest as shown in Figure 3 and 4 is indicated.
TMJ = temporomandibular joint, arrow points to the nervus auriculotemporalis.

One of the last patients operated on in our department (but not evaluated in this group) who complained of Frey's syndrome underwent an exenteratio orbitae, a parotidectomy, and a neck dissection because of a metastatic malignant adenocarcinoma of the glandula lacrimalis. For this operation, the incision was far more cranial. Consequently, the upper border of the tragus and the cutaneous branches were included in the excision. This was, of course, an extended type of surgery, which in itself entails greater risk.

SMAS interposition alone has had good results, according to other authors. Yet we think that our rather caudal incision and the blunt preparation of the tragus minimizes the damage to the cutaneous branch of the auriculotemporal nerve in this area. Most importantly, by performing only a PSP, we preserve the fibres extending from the auriculotemporal nerve and joining the facial nerve. This, in our opinion, is another step forward in the prevention of Frey's syndrome.

We therefore advise using an incision that does not go beyond the upper border of the tragus to prevent Frey's syndrome. To that end, we recommend just a PSP and the modified SMAS interposition as described by Casler and Conley when performing parotid gland surgery for superficial lobe tumours.

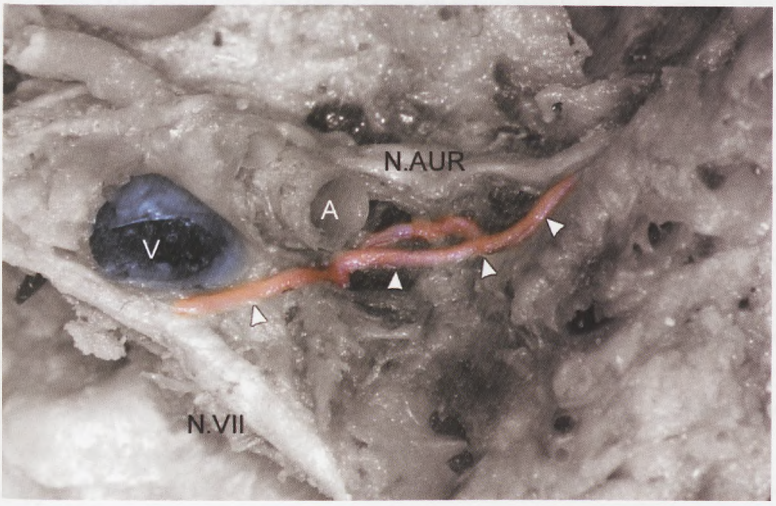

Figure 3. Same area as shown on Figure 2; facial nerve upper branch is retracted backwards and somewhat laterally and shown from infero-medial angle. Computer manipulated to show the auriculotemporal nerve (N.AUR) with its crosslinks (red) to the upper division of the facial nerve and their relation to the retromandibular vein (V) -lumen in blue- and the external carotid artery (A). As shown, the branches of the auriculotemporal nerve (arrowheads) pass underneath the level of the vessels.

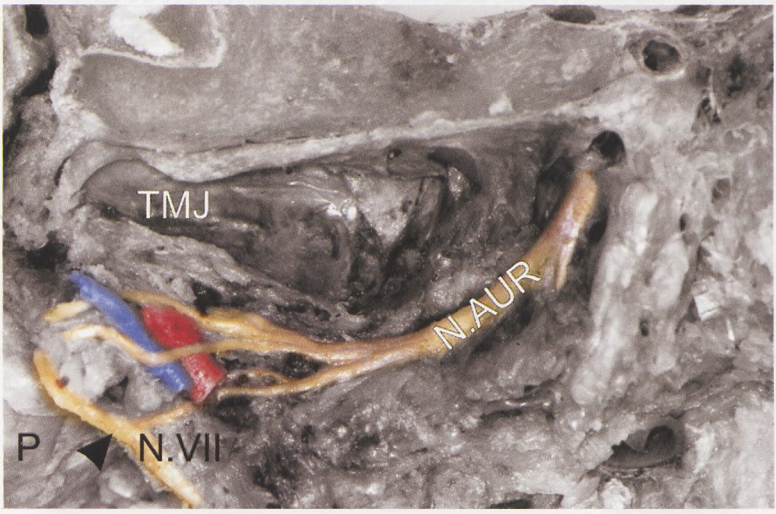

Figure 4. Same area as in Figure 2 and 3, shown from a more lateral angle. Besides the branches from the auriculotemporal nerve that crosslink with the facial nerve, also the cutaneous branches and their cranial position in relation to the tragal cartilage (P = 'pointer') are shown. N VII = upper division of facial nerve (retracted laterally thus showing the medial side), N. AUR = auriculotemporal nerve with its branches to the facial nerve passing underneath the vessels, and the cutaneous branches crossing on top of the vessels.

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8

Papillary cystadenoma lymphomatosum (Warthin's tumour) and smoking

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Introduction

Papillary cystadenoma lymphomatosum, or Warthin's tumour (WT), is a benign, slow-growing neoplasm. This tumour has two components: a double-layered eosinophilic epithelium, and a lymphoid stroma with germinal centres. Though occasionally found in submandibular glands and cervical/periparotid lymph nodes, the tumour occurs primarily in the parotid gland. This monomorphic adenoma was first described by Hildebrand in 1895, but the lesion is named after Aldred Scott Warthin, an American pathologist who reported two cases in 1929. Accounting for 10 to 14% of all epithelial neoplasms of the salivary glands, it is the second most common benign tumour of the parotid gland. Frequently (in 8 to 19% of all cases) found in multiples and bilaterally, some reports mention recurrence and even a very low malignant potential.[1,2,3,4,5,6,7] Men have a higher incidence of WT, though it has increased in women over the past few decades.[2,3,5] This tumour affects predominantly white persons, so, though WT does occur in other racial groups, genetic factors may play a role.[1,2] Most of those affected are between 55 and 70 years of age.
The precise aetiology of this tumour is still unknown. One hypothesis concerns its characteristic lympho-epithelial coexistence. WT is said to arise from the neoplastic proliferation of heterotopic salivary gland ducts that migrated into the intraparotid or paraparotid lymph nodes during embryogenesis. Groups of salivary ducts and acini may become included in such lymph nodes. Neoplastic proliferation of the parotid ductal epithelium could then participate in the development of WT.[6,8]

In an evaluation of pre- and post-operative care for patients with parotid gland tumours, we noticed that patients with a WT were heavy smokers. Recent evidence from the literature also suggests a correlation between (cigarette) smoking and the development of WT. Most men (81 to 96%) and women (67 to 82%) with a WT have a history of smoking. But among patients with a pleomorphic adenoma (PA), the most common benign salivary gland tumour, smoking is less prevalent (30 to 46%), though the overall incidence of smoking in the United States was 28% in 1985.[2,5,6] In a British study, only one out of 63 patients with a WT was a non-smoker, whereas 31 out of 75 patients with a PA had never smoked. Furthermore, patients with a WT smoke more heavily than patients with a PA and a positive history of smoking.[1,5,8,9,10]
Thus, tobacco smoke could be the main irritating factor provoking the epithelial duct metaplasia and inducing the lymphocyte proliferation.[5,6] In order to investigate a

correlation between smoking and the development of WT in our patients, we reviewed their smoking history.

Materials and Methods

All patients diagnosed with a WT who had been entered in the database of our pathology department between 1988 and 2003 were included in the present study. Smoking habits were assessed on the basis of clinical records and discharge letters in the hospital database. Two control groups were used: patients with a PA who had been operated on during the same period; and patients visiting the audiology department between July and September 2004. The discharge letters were checked for the first control group (PA patients). Patients in the second control group were asked to fill in an anonymous questionnaire.

Table 1. Number of patients, mean age at surgery (standard deviation), their sex, and percentage with a positive smoking history among A) patients operated on for Warthin's tumour, B) patients operated on for pleomorphic adenoma, and C) patients visiting our audiology department.

	Patients	Mean age (SD)	Sex (m/f)	Smoking (%)
A (Warthin's)	79	60.1 (9.6)	48/31	97.5
B (pleom. ad.)	78	48.6 (15)	51/27	59
C (audiology)	46	51 (14.9)	19/27	56.5

Results

Of the 89 patients with a WT, the smoking history was known in 79 cases (48 male, 31 female). Among the men, one patient (1.3%) had stopped smoking 15 years ago, but the rest were active smokers. Two of the women had never smoked. One of them was a pub owner who was customarily among people who were smoking. Overall, 100% of the men and 93.5% of the women in this group had been or still were smokers.

The number of cigarettes consumed each day ranged from 1 cigar/5 cigarettes to 40 cigarettes. The mean age on the date of surgery for the WT group was 60.1 years (SD 9.6). There were more heavy smokers among patients under 60, with a mean of 17.8 cigarettes per day; those over 60 smoked 14.1 cigarettes a day.

Out of the 235 patients with a PA in the parotid gland, the smoking history was known in 78 cases (51 male, 27 female). In this group, 58.8% of the men and 59.3% of the women had been or still were smokers. Eight (10.3%) had quit, but the rest were still active smokers. The mean age on the date of surgery was 48.6 years (SD 15). In patients with a PA and a positive history of smoking, the mean quantity of cigarettes smoked by those under 48.6 years of age was 14.7 per day; in the group older than 48.6 years, the mean was 15.6 per day.

Patients under 60 with a PA and a positive history smoked 14.3 cigarettes per day, while those over 60 smoked 18.9 a day. Of the 46 people in the control group, 26 had a positive history of smoking. Only 12 of these were still active smokers. In this group, 14 patients (30.4%) had quit smoking. Among those who had not, the men smoked a mean of 8 cigarettes each day, the women 11. For further information, see Table 2.

Discussion

The percentage of smokers in our group of patients with a WT was very high. But the age composition of this study population should be kept in mind. Since smoking was very common a few decades ago, it would not be unusual to find a high share of smokers in an elderly group of patients. Our observation that WT seems to be associated with smoking concurs with findings in the literature. Thus, our findings would appear to be reliable. In that light, we postulate a relation between tobacco use and the development of a WT. It may take a long time for a tumour to develop, which would explain why a WT occurs in later life. The increase of WT tumours in women over the past few decades may be the result of higher smoking rates among women, as hypothesized by others.[2,3,6] Furthermore, there is a tendency for patients who develop a WT at a younger age to be heavier smokers than the older patients with a WT. This is in contrast to the PA control group, in which younger patients with a positive history of smoking tend to smoke less than older patients. (This might be explained by an overall decline in smoking habits, however.)

Table 2. Percentage of patients with a positive smoking history among patients with A) a Warthin's tumour, B) a pleomorphic adenoma, and C) a control group visiting our audiology department, by their age in years. For comparison, the overall percentage of active smokers in the Netherlands for the age groups 35-49, 49-64, and 65+ in D) 1990 and E) 2003 is also shown.[11]

	A	B	C	D	E
M < 49 (35-49)	100	61.5	66.7	43	40
M < 60 (49-64)	100	69.4	64	41	31
M > 60 (65+)	100	35.7	80	34	16
F < 49 (35-49)	100 (n = 1)	73	50	36	34
F < 60 (49-64)	100	54.5	45.5	29	25
F > 60 (65+)	80	40	60	12	15

M = male, F = female

We decided to use two control groups in our investigation. The first one has the advantage that the tumour was in the same organ, but it has the disadvantage of a younger age distribution. Another drawback of using PA patients as a control group is that this type of tumour may also be smoking related. This possible similarity might lead us to underestimate the importance of smoking in the pathogenesis of WT. In addition, smoking rates in the Netherlands have declined in recent years among older men (aged 65+) and increased for women.

The disparity in smoking rates between PA patients and those with a WT may be fully attributed to the age and sex composition of the control and study groups. However, even within groups that are comparable with respect to sex and age, as reported in the literature, smoking is more prevalent among patients with a WT. Furthermore, in most studies, the association between smoking and the development of a WT is consistent with our findings, even after stratifying for age and sex.[7] We found that the incidence of smoking is much higher in patients with a WT compared to those with a PA.

The second control group is representative of patients visiting an ENT specialist with diseases that are known not to be related to smoking. To fit this profile, we selected patients visiting our audiology department. They too smoke much less than our study population.

The overall percentage of active (as distinguished from passive) smokers in the Netherlands varies from 15 to 43% for groups in the same age range. This share is much lower than in the group of patients with a WT (96.2%).

If smoking is a factor in the development of a WT, the next question we must address is what provokes the pathogenesis of WT.

The lymphoid tissue of WT resembles the mucous membrane of the small intestine in several respects: lymphoid tissue is closely associated with the surface epithelium; B cells predominate in the lymphocytic population; a significant sub-population of these B cells bear IgA on the surface; and most plasma cells in the vicinity of the basement membrane produce IgA. This similarity suggests that the epithelial part of the WT, like the intestinal epithelium, plays an important role in the immune response.[4] On the basis of morphological similarities between some organ-specific immune disorders and WT, Pinkston and Cole suggested that WT might be the result of an immune reaction of the delayed hypersensitivity type.[1]

Ogawa et al. demonstrated the expression of MHC class II antigens on the epithelial component of WT, showing analogies to Sjögren's syndrome.[4] They concluded that the epithelial cells of WT might have the potential to act as an antigen-presenting cell with the capability to activate lymphoid stroma. According to the literature, the antigen may come from the cystic content of the WT, as most plasma cells of the tumour produce IgA, which is secreted by the tumour epithelium into the cystic lumen. However, no tissue destruction indicative of an auto-immune pathology is found in WT. These authors concluded that the antigen, if any, presented by the tumour epithelium comes from outside the tumour cell.[4] Perhaps one of the many substances in cigarette smoke acts as an antigen.
It has also been postulated that tobacco abuse is often accompanied by poor oral hygiene and associated with an increased incidence of local inflammatory diseases as well as increased susceptibility to respiratory bacterial and viral infections. Therefore, tobacco smoke could increase the risk of infection with the Epstein-Barr virus, for example.[5]

Mitochondrial DNA deletions might play a role in tumour genesis.[12] Tumour-specific mitochondrial point mutations have been observed in a range of cancers. In lung tissue taken from smokers, the level of mtDNA mutations including deletions and base substitutions is higher than in tissue from non-smokers.[12] The 4977mtDNA deletion is more often present

in the parotid gland of elderly patients than in younger patients. An elevated level of 4977BP mtDNA deletion is also present in the mitochondrial DNA (mtDNA) of WT. But although the level of specific base substitutions in the parotid tissue of smokers is higher than in non-smokers, there is no difference in the level of the 4977BP deletion in the parotid tissue of smokers compared to non-smokers.[12]

The report prepared by the Dutch Committee for Head and Neck Tumours (NWHHT) on parotid gland tumours does not mention a correlation between smoking and the occurrence of parotid gland tumours. The absence of such a relation is especially striking in the section on papillary cystadenoma lymphomatosum. We believe that our study provides grounds for conducting more research on the aetiological factors of parotid gland tumours.

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9

Grading facial nerve function: analysis of the most frequently used systems; why a new grading system should be proposed

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Introduction

To evaluate the efficacy of various interventions for facial nerve paresis/paralysis, clinicians need an objective, reliable grading scale to quantify, describe, and compare abnormalities of function.[1,2,3] Such a grading scale should be sufficiently sensitive to measure the natural course of facial disability, from the onset of paralysis to the various states of recovery, and to detect changes over time or following treatment. Also, the scale should have a high grade of reproducibility in measuring the impairment as well as the disabilities, i.e., the impact of facial dysfunction on patients' quality of life (QoL).[1] (Impairment refers to physiological and anatomic abnormalities; disability refers to functional issues such as discomfort and difficulty in activities considered usual for an individual such as eating and communicating.) So even though one might be tempted to use objective measurements only, we - like others - believe that useful information is obtained by asking the patient to estimate his own recovery.[1,4]

However, the measurement of facial nerve function in a consistent, reliable manner has proven to be difficult.[5] This difficulty stems from the complexity of facial nerve physiology. Not only does the nerve control multiple motor regions of the face, it also controls special functions such as lacrimation, salivation, and taste.[5] Injuries cause varying degrees of dysfunction to some or all of these functions. So besides facial paralysis and asymmetry at rest, lesions to the facial nerve might also cause hyperacusis, dysgeusia, and crocodile tears. Another factor complicating the evaluation is the effect of aberrant facial nerve regeneration after injury. This aberrant regeneration might lead to secondary defects as synkinesis, contracture, and hemifacial spasm, which contribute to overall disfigurement and decreased QoL and are therefore difficult to ignore, but also difficult to score.[5] Any composite measure of overall facial nerve function must therefore attempt to qualify or quantify these different types of function in a single common scale.
Further complicating the development of a standard measurement is the subjectivity of description of facial expression. For this reason, systems based solely on objective measurements have been developed. However, these often involve precise measurements and mathematical calculations and may therefore be tedious and time consuming, rendering them impractical for rapid assessment by the average observer.[1] Furthermore, the degrees of movement and facial co-ordination normally differ from person to person because, for example, some people have more expressive faces with larger smiles and greater eyebrow

excursions than others. Therefore, an absolute scale of appearance and movement is not practical.

Grading systems can be divided into three categories: gross, regional, and specific. Gross systems were presented by Botman and Jonkees, Peitersen and May. These were unweighted. However, the Botman and Jongkees, May and Peitersen gross scales are inadequate to define all facial nerve functions.[2,3,7]
Regional systems require the observer to assess different areas of the face independently. Regional scores can be expressed as a nominal scale or as a percentage of normal. Additionally, regional systems can be weighted or unweighted.[7] Weighted means that certain areas of the face are given less importance, either because they are less likely to recover, or because they are considered of less functional or cosmetic importance.[3]
Specific systems address the presence or absence of various associated symptoms (for example hyperacusis) and signs (for example ectropion).[3,7]

House found that regional scales were more reliable, whereas gross scales were more practical and preferred by most observers because of their simplicity.[6] His conclusions were that gross scales correlated equally with regional and specific scales, indicating that the added amount of detail in the more complex grading systems was unnecessary.[5] His requirements for an effective facial grading scale were that scoring should differentiate between patients who are different, that it should represent something meaningful, and that the scoring scale should measure secondary defects in addition to measuring facial movement.[1] He intended his scale to group patients into simple categories for observation and comparison.[5,7]
The House-Brackmann Grading Scale (HBGS) was introduced by House and Brackmann in 1985.[8] This scale is based on two articles by these authors.[3,4,7] House proposed a descriptive scale based on his analysis of pre-existing grading systems. Brackmann provided an objective scale; this scale measured eye and mouth movements on the affected side and compared these with the normal side. The system involves a six-point scale with I being normal and VI total paralysis (see Table 1). The Facial Nerve Disorders Committee of the American Academy of Otolaryngology-Head and Neck Surgery adopted the HBGS as the standard for grading facial nerve recovery. Nowadays, every other scale should be converted to the HBGS if results are reported in Otolaryngology-Head and Neck Surgery (and most other journals as well).[3,5,8] The HBGS is used and widely accepted mainly because of its ease of use.[6] It is supposed to be clinically sensitive and technically undemanding.

Table 1. Facial nerve grading system according to House and Brackmann

Grade	Description	Characteristics
I	normal	normal facial function in all areas
II	mild dysfunction	gross: slight weakness noticeable on close inspection; may have very slight synkinesis at rest: normal symmetry and tone motion forehead: moderate to good function eye: complete closure with minimum effort (slight asymmetry) mouth: ability to move corners of mouth with maximal effort (slight asymmetry) no synkinesis, contracture, or hemifacial spasm
III	moderate dysfunction	gross: obvious but not disfiguring difference between two sides; no functional impairment; noticeable but not severe synkinesis, contracture, and/or hemifacial spasm at rest: normal symmetry and tone motion forehead: slight movement eye: complete closure with effort mouth: ability to move corners of mouth with maximum effort
IV	moderately severe dysfunction	gross: obvious weakness and/or disfiguring asymmetry at rest: normal symmetry and tone motion forehead: none eye: incomplete closure mouth: asymmetric with maximum effort secondary defects severe enough to interfere with function
V	severe dysfunction	gross: only barely perceptible motion at rest: asymmetry motion forehead: none eye: incomplete closure mouth: slight movement
VI	total paralysis	no movement

The major criticisms of the HBGS have been its inability to distinguish between finer grades of facial nerve dysfunction, the subjective nature (resulting in high inter-observer variability), and the way in which it addresses the secondary defects of facial nerve function.[5] All facial nerve grading systems accurately evaluate normal facial function and total paralysis, but difficulty exists in assessing intermediate function and function that is dissimilar across the face.[6] House already noted that subjective scales have a good inter-observer reliability nearer to the extremes of function, and that there is considerably less agreement within the intermediate degrees of impairment.[5]

In gross scales like the HBGS the assignment of a global score (single number) to communicate the function of several different branches necessarily sacrifices the amount of information conveyed.[5,6] The differences between the grades are at times difficult to assess, because patients may have contrasting degrees of function in upper and lower parts of the face.[9] So, in patients with dysfunction that is dissimilar across the face, the single House-Brackmann score does not fully communicate their facial function. Rickenmann pointed out that all patients following facial nerve grafting by Fisch fell into grade III of the HBGS, although they were clinically different.[6,7,9] Also, in the instance of a patient being monitored for facial nerve paresis following parotidectomy, the same HBGS grade may be assigned for weeks or even months, despite clinically apparent improvement within that same time interval. The variation of function within one grade seems thus too wide for adequate classification of surgical results.[9]

In addition, the single grade does not always correlate with the best or worst function along the facial regions.[5] One study found that the worst score using the HBGS was lower (thus indicating better function) than the worst regional scale in 79% of the patients. This implies that the HBGS does not represent the most affected area of the face.[6]
In a patient with variable weakness along the different branches, the emphasis is often on the ability of the eye to close. The HBGS also correlated most strongly with the regional scoring of the eye.[6] This is in agreement with Brackmann, who stated that the eye is the most important functional aspect of facial nerve recovery.[4,9] However, although the protection of the eye is of primary importance, achievement of good eyelid closure is easier to accomplish than a good smile, and symptomatic eye problems are not always predicted by the degree of eye closure difficulty. Furthermore, the smile has a greater impact on the aesthetic appearance of the patient.[1,9]

Another clinical problem encountered by clinicians was that in some patients the facial nerve function fell into more than one category of the HBGS. In the beginning the mere presence of secondary defects limited the observer to grade III or higher discounting any evaluation of motor function. The difference was determined by the subjective scoring of the defects as 'severe enough to interfere with function or not', but the motor function could be better than grade III. In the modified HBGS, slight synkinesis is now allowed in grade II. Thus, overall, the weight of the impact of secondary defects has been decreased.[5,6]

At the moment there are still no qualifying comments regarding secondary defects at grades IV through VI.

Although the HBGS is currently the accepted facial grading system, it shows only a moderate overall degree of inter-observer reliability. Rickenmann pointed out that the HBGS did not meet the international standard of 0.8 for inter-observer reliability.[3,9]
With the development of newer techniques for facial nerve repair and protection, there is a clear need for a more graduated, continuous scale to report and compare results, since application of gross scales would fail to distinguish subtle differences in facial nerve recovery.[5] The use of a regional scale may prevent this problem by providing more information about the function of the major branches of the facial nerve.[6]
Several other methods that offer potential improvement compared with the currently accepted standard have been developed.[5]

Review of other current grading systems

Yen et al. developed a regional six-point scale based on the HBGS because they noted a limitation of the HBGS due to its reduction of facial nerve function to a single number. Using six grades for each division of the face and by grading synkinesis as none, mild, or severe, they could overcome this limitation.[6]

The Burres-Fisch Linear Measurement Index (BFLMI) measures the displacement of anatomic landmarks of the face at rest and during various expressions. These measurements are then mathematically converted to arrive at the BFLMI. A scale like Burres-Fisch relying solely on objective measurements has the benefit of eliminating observer bias and subjectivity. But a drawback is that the calculation of the linear measurement index is a time-consuming process, and it is thus unlikely to be a practical tool for the busy clinician.[3,5,6,10]

The Fisch Detailed Evaluation of Facial Symmetry (DEFS) assesses the face in five different poses and rates each pose with a percentage score. These percentage scores are converted to a weighted score with a maximum of 100. By adding the patients' ability to whistle to four

standard poses, the DEFS emphasizes the aesthetic and functional weight of the mouth in the evaluation of the overall recovery of facial movement. Rickenmann et al. found the DEFS scoring to be more reliable than the HBGS.[6,9]

The Nottingham System (NS) measures two distances at rest and at a maximum effort during three different motions. The differences between rest and maximum effort are added together for either side, and the lower value is expressed as a percentage of the opposite side. The second step assigns a letter for either absence (A) or presence (P) of any of the following: hemifacial spasm, contractures, and synkinesis. The third step likewise assigns a letter for absence (N) or presence (Y) of gustatory sweating, dry eyes, or dysgeusia. Thus, the NS separately evaluates the secondary defects. The NS proposed a simplified version of the BFLMI. It was developed with the intention of preserving objective measurements in the spirit of the Burres-Fisch system, with modifications to allow more rapid assessment for use in the clinic and also to incorporate secondary defects. The composite NS score is expressed in a fashion similar to the TNM classification used for cancer staging of tumour, nodes, and distant metastasis. The NS can be performed rapidly (three minutes), it correlates with the HBGS, and it demonstrates lower within-group variability than the BFLMI. It is a rapid, unbiased, accurate assessment of facial function in the clinic. Additionally, the lettering system is useful as a descriptive modifier.[3,5,6,11]

The Sunnybrook scale - or Toronto Facial Nerve Grading System (TFGS) - is a weighted, subjective scale with incorporation of secondary defects into a single composite score. It uses a worksheet to separately assess resting symmetry, symmetry of voluntary movement, and synkinesis compared to the unaffected side of the face. The symmetry of movement and synkinesis are scored for five different motions. Resting symmetry is scored for three regions. The values are then used to calculate a composite score. The final score ranges from 0 for complete facial paralysis to 100 for normal facial function. The TFGS composite score was reported to be more sensitive than the HBGS in classification of facial nerve recovery and to have a good inter-observer reliability.[2,3,6,12] Some authors demonstrated the superiority of the TFGS over the HBGS. They believed that the TFGS is superior to other scales by virtue of its sensitivity, comprehensiveness, ease of use, and inter-observer reliability. It scores with a wider response range than the HBGS. It is simpler, more reproducible, and faster than linear measures, inexpensive, and brief enough to be compatible with clinical practice.[2]

The intra- and inter-observer variability of this system are excellent. Some authors suggested that the TFGS should be applied whenever accurate and precise documentation is required.[3,5,13]

Adour and Swanson proposed a weighted system that consisted of physical measurements of the frontal, eye, and mouth regions of the face on the paralysed compared with the normal side. The difference was expressed as a percentage. This percentage was then converted into a numeric value on a scale from 0 to 4. Weighting was unequal, with 40% each given for the eye and mouth and 20% to the forehead. Secondary effects were negatively incorporated in the final score (the Facial Paralysis Recovery Index). This scale did not consider the face at rest.[3,14]

Stennert proposed a double-weighted system. It considers the face at rest (weighed at 40%) and in motion (weighed at 60%). The different regions of the face are also weighed with the mouth given 50% of the weight. Secondary effects are scored separately.[3,15]

In Japan the Yanagihara system is generally used. This is a 40-point grading scale based on 10 functions of the face. Recently, a conversion table was made relating this scale to the HBGS. The HBGS I to VI grades are comparable to a score of 0, 8, 16, 24, 32, 40 on the Yanagihara scale.[16]

The Facial Clinimetric Evaluation scale (FaCE) is a reliable patient-based grading scale. This system seems better than traditional scales for evaluating QoL issues.[1]

Some use technologically generated tools. But these technologically driven instruments require additional time and resources for data collection and processing. In fact, video recording, photography, and computer programs are to a greater or lesser degree expensive and time consuming. Few are used in a clinical setting.[1,3]

Another new system

Although many different systems have been developed, most grading instruments focus on facial appearance and movement.[1] But different degrees of movement may not necessarily translate into different degrees of disability.[1] A person's ability to feel physically normal may not be predicted by smaller differences in facial movement. Because the impact of facial

paralysis on QoL is high, a grading scale should also take patients' values into consideration. Except for the FaCE scale, little has been done so far to incorporate the disabling results of facial paralysis such as oral incompetence, communication difficulty, eye irritation, excessive lacrimation, pain, and social stigmatization in the grading system.[1] We agree with other authors who stated that the TFGS is better fit for indicating small differences in function than the HBGS. There is, though, a sense among several authors that reliably measuring intermediate levels of facial dysfunction and differentiating subtle differences is difficult and is not achieved with currently available grading instruments.[1] A gold standard for measuring facial movement has not yet emerged.

During a study in which we followed up patients on whom parotid surgery was performed, we noted a difficulty in classifying our patients within one grade of the HBGS, especially if only one of the nerve branches had been damaged. Therefore, we developed a new system for grading facial nerve disorders. This system uses the 'generally accepted' goals of an ideal facial nerve grading system combined with the best issues of the above-mentioned scales:
1) universality and reproducibility with low inter-observer variability;
2) incorporation of measures of both static and dynamic components of facial muscle function;
3) regional scoring;
4) acknowledgement of the secondary defects of facial nerve dysfunction;
5) subjective scoring by the patient;
6) convenience and ability to be performed at low cost and in a minimal amount of time.[1,5]

We think that our system, that is quite similar to the TFGS, even makes some improvements upon the TFGS. Our system is not weighted by the physician, and it takes secondary defects other than synkinesis into account. The TFGS does not grade subjective patient symptoms.

The system we developed is called the MoReSS. This stands for Movement, Rest, Secondary defects, and Subjective scoring.

The new system: MoReSS

Anatomic background

The intraparotid facial nerve bifurcates in a temporofacial and a cervicofacial trunk. These usually divide into five main divisions. These are the temporal, the zygomatic, and buccal branches from the temporofacial trunk, and the mandibular branch and ramus colli from the cervicofacial trunk. There is much overlap in the innervation of these target areas. Especially the temporal division, with one or two branches to the frontal area and the remainder to the zygomatic and buccal area, has numerous interconnections.[17,18,19]

We did not take much note of the ramus colli, since this branch does not seem very important in case of dysfunction. The other groups were separately addressed, although we are aware of some overlap. The groups are as follows: the rami temporales for the forehead; the rami zygomatici for the eye; the rami buccales especially for the midface and upper lip; and the ramus marginalis mandibulae for the lower lip and chin. This practical categorization into four regions has recently been used by others as well.[20]

Assessment

These regions are evaluated during movement and at rest. Next, the secondary defects, if present, are counted. Finally, patients are asked to score the severity of their dysfunction with a single grade. Zero means normal function, 10 most severe dysfunction. In this way a total score of Mo 12, Re 8, S 6, and S 10 can be obtained. In case of dissimilar paresis, an extra letter can be assigned for the paralytic branch. For example, we may score as follows: Mo 6 ab, Re 4 ab, if the forehead and eye have gross asymmetry at rest and the eyebrow cannot be elevated, the eye cannot be closed, and there is no movement in the forehead, while there is normal function and symmetry in the lower part of the face.

(For scoring table, see Figure 1.)

To compare the MoReSS to the HBGS, a study is currently being performed in which all patients with a facial nerve paresis/paralysis visiting our outpatient clinic or following surgery are graded by three different doctors while blinded for the results of the others.

Physicians are provided with printed descriptions of both the HBGS and the MoReSS. They are then asked to report facial nerve function using the traditional HBGS and our new grading system.

Discussion

Whether a system relies on linear measurements, topographic mapping, mathematical manipulation, or subjective terms such as 'mild' and 'obvious', the end result should convey a picture of the extent of facial nerve dysfunction to the user. It should provide a viable medium for clinical communication and follow-up changes.[3,6] It should also be simple, clinically sensitive and relevant, reproducible, informative, and easy to use (requiring little time and expense). It needs an easy categorization, especially for reporting purposes.[3]

	Movement	Rest	Secondary defects	Subjective
	0 = no disorder 1 = mild disorder (movement almost complete) 2 = serious disorder (slight movement) 3 = no movement	0 = no asymmetry 1 = mild asymmetry 2 = serious asymmetry	- synkinesia (a) - hemifacial spasm (b) - contracture (c) - crocodile tears (d) - hyperacusis (e) - dysgeusia (f)	0 = no complaints 10 = serious complaints
Forehead: (a)		0-3	0-2	Number of secondary defects
Eye: (b)		0-3	0-2	
Upper lip: (c)		0-3	0-2	
Lower lip:(d)		0-3	0-2	
Total	Mo .. 0-12	Re .. 0-8	S .. 0-6	S .. 0-10

Movement
The degree of movement of the four facial regions is assessed in comparison to the non-paralytic side.
Forehead: a = wrinkling / frowning
Eye: b = complete closure
Upper lip: c = showing upper teeth / smiling
Lower lip: d = showing lower teeth / pouting

Rest
Assessment of the degree of symmetry at rest comparing the non-paralytic and the paralytic side.
Forehead: a = wrinkles
Eye: b = width of eye slit
Upper lip: c = nasolabial fold
Lower lip: d = asymmetry of the corner of the mouth

Figure 1. Scoring table and description of the MoReSS grading system for facial nerve disorders.

Although our subjective scoring system may be prone to inter-observer variability, we think that by separating different regions of the face and by not making the choice of options too extensive, we offer a reliable grading system. With the possibility to assign a letter to indicate the paralytic area, it is easier to look for changes in function during follow-up. Furthermore, with our system we created more variations to distinguish patients that would otherwise fall into the same HBGS grade. We deliberately did not weigh the different areas or the different categories ourselves but rather kept them distinct in our grading system. With the use of our system, the weighing is done by the patient. We think that facial nerve paralysis is most of all an individual's handicap that cannot be weighed solely by what physicians think is important. For example, although shedding light on the degree of injury, the precise clinical impact of synkinesis is unclear.[1] Furthermore, we think that when using the letters this system more clearly indicates which part(s) of the complex physiology of the facial nerve is (are) affected. The MoReSS, like the TNM classification and the Glasgow Coma scale, is, in our opinion, an easy-to-use, unweighted scale that makes follow-up and comparison of treatment outcomes more precise. Further study will be needed to ascertain whether it is also highly reproducible.

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Treatment strategy for parotid gland tumours; implications of our research

J.A. de Ru

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Suggestions and discussion

Diagnostic procedures

Over the past few decades, the diagnostic work-up of parotid gland tumours has changed drastically. Many different pre-operative diagnostic tests have become available for clinical practice. Ultrasound (US), CT scanning and Magnetic Resonance Imaging (MRI) are often used. The images have improved and will improve further with the more advanced types of scanners. Experienced cytopathologists are able to predict the benign or malignant nature of the tumours with high accuracy using fine needle aspiration cytology (FNAC). This thesis evaluates the role of these pre-operative diagnostic tests. It concludes that the emphasis of our routine pre-operative programme should be on the cytology. When an experienced cytopathologist obtains high-quality punctates, the incidence of incorrect predictions about the nature of a tumour will be very low. Therefore, we advocate using FNAC in all patients with a parotid gland tumour, as was discussed in chapter 5. Recently, our cytopathologist was very helpful in demonstrating how to obtain the right material. From now on, all ENT residents will visit the pathology department for training in FNAC. We think that lessons in FNAC can be very helpful for the clinician, as they will improve the outcome of the diagnostic test tremendously.

When a tumour is diagnosed as benign according to FNAC, and on palpation it is judged to be easily removable, MRI and US will be of limited additional value, as was shown in chapter 5. It will be necessary to evaluate our suggestion not to perform MRI prospectively in these cases. If imaging techniques such as MRI are used, in the future more research and attention will have to be directed toward visualizing the facial nerve itself. None of the anatomic landmarks used so far to predict the course of the facial nerve in the parotid gland are 100% accurate. Some new techniques seem promising and claim to visualize the intraparotid facial nerve in 85 to 90% of cases. Nonetheless, the clinical relevance needs to be established before any technique can be universally accepted as the gold standard.[1]

Surgery

Surgical procedures have changed from radical procedures to more limited ones. Nowadays, the preferred surgical technique for a benign (or low-grade malignant) tumour in the superficial lobe of the parotid gland is partial superficial parotidectomy (PSP). There is no need for total superficial parotidectomy, because the limiting surgical margin of the resection

is determined by the relation of the tumour to the facial nerve. Pleomorphic adenoma will recur if excision is not performed radically. Therefore, we advise the removal of a margin of healthy parotid gland tissue, i.e., a PSP, along with the tumour, if possible, instead of performing an enucleation. This might prevent rupture of the (pseudo)capsule of the tumour. With this technique we did not have any recurrences in a one-year follow-up of our primary benign cases. Although recurrences might be demonstrated even after 10 years, we did not have to operate on any recurrences of our primary surgery for benign tumours during the last five years. We therefore conclude that PSP is a safe technique for benign tumours of the superficial lobe.

When performing parotid gland surgery, the fissura tympanomastoida can be of great help in locating the main trunk of the facial nerve, as shown in chapter 2. We demonstrate that this landmark can be very helpful in an anatomic study. In clinical practice, the pointer and the posterior belly of the digastric muscle are still frequently used as well. A microscope is often used to help in the search for the main trunk. Identification of the main trunk (and its branches) before tumour removal, the anterograde technique, demonstrates a very low percentage of permanent facial nerve injury. All primary cases operated on for benign tumours had a normal facial nerve function after six months. We recommend the anterograde technique for locating the facial nerve during parotid gland surgery. In this study we could always rely on this technique. Only if a very large tumour obscures the area of the foramen stylomastoideum might it be necessary to return to a retrograde technique.

Complications and distressing side effects of surgery

Since the complications with the most impact on a patient's quality of life (recurrence of tumour and facial nerve paresis) are dramatically reduced, more attention is focussed on other complications. For example, the literature reports a high incidence of Frey's syndrome when a starch-iodine (SI) test is performed. However, not many of our patients complain about this syndrome. Therefore, SI testing was performed as a routine evaluation at one year post-operatively. A very low incidence with a minimum clinical relevance was demonstrated in chapter 6. The technique we used during our operations has also been demonstrated in the literature to reduce the incidence of gustatory sweating. Our technique starts with an incision on the caudal side of the pointer. This might preserve the cutaneous branches of the auriculotemporal nerve. Furthermore, only a PSP is performed, probably sparing the branches of the auriculotemporal nerve that run medial to the retromandibular vein and connect to the

facial nerve. These are said to be the main branches carrying the parasympathetic information to the parotid gland. Finally, if possible, the superficial musculo-aponeurotic system (SMAS) layer and the remaining parotid gland tissue are sutured backwards to the sternocleidomastoid muscle. In this way, the surgeon creates a barrier for sprouting parasympathetic nerves, which at the same time provides new 'target tissue'. Using this technique, we did not have to give any botuline toxin injections to alleviate serious symptoms of Frey's syndrome in any of our primary operated patients over the past few years. We recommend this technique to specialists performing parotidectomy.

A complication of parotid gland surgery that has been getting more attention recently is the sensory deficit that exists due to sectioning of the great auricular nerve (GAN). Preservation of this nerve takes only about 10 minutes.

Neuroma formation can easily occur after sectioning of the GAN. Because neuroma formation can have a high impact on the quality of life, the subject of preventing neuroma formation deserves more study.

For the follow-up and comparison of treatment outcomes, we suggest using the new MoReSS system as described in chapter 9. We think that this new system is more apt to demonstrate iatrogenic paralysis of one branch of the facial nerve following surgery. Furthermore, this system might be better for indicating slight changes in function. Finally, this system incorporates the patient's own 'weighing' of his facial nerve function in the scoring.

Literature

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Summary
Samenvatting in het Nederlands
Dankwoord
Curriculum Vitae

J.A. de Ru

Chapter 1 presents a general introduction to the background of this thesis.

The aim of the study, presented in chapter 2, was to identify a reliable method for locating the main trunk of the facial nerve near its exit from the foramen stylomastoideum. The literature describes many different techniques that are used for this purpose. In our clinic, a part of the tragal cartilage - 'the pointer' - was generally used. The findings in this study demonstrate that the fissura tympanomastoidea is the most reliable landmark in vitro.

Chapter 3 describes the findings of an anatomic study regarding different lines for indicating the intraparotid course of the facial nerve. If the course of the facial nerve is known, one can differentiate superficial lobe tumours from deep lobe tumours. Deep lobe surgery requires more operating time and more extensive manipulation of the facial nerve. Therefore, pre-operative knowledge about the tumour location may help in the planning of the procedure and in patient counselling. Because the facial nerve itself cannot be visualized, many authors predict its intraparotid course using different landmarks. None of the landmarks used so far is 100% accurate. Using the close and constant relation between the facial nerve and the retromandibular vein that we noticed during our first study, two lines were developed for predicting the intraparotid course of the facial nerve. These lines were compared to the Facial Nerve line described by Ariyoshi and Shimahara. One of the lines, called the U line - connecting the most dorsal point visible of C1 or C2 vertebrae to the retromandibular vein - seemed to be a better indicator for the intraparotid course of the facial nerve than the FN line.

Therefore, a retrospective study was performed to demonstrate the usefulness of the U line in clinical practice. Chapter 4 presents the outcome of this study.
Again the U line seemed to be a reliable addition in the pre-operative work-up. This might be due to the fact that the retromandibular vein, like the facial nerve, is located in the parotid gland tissue itself. Therefore, a parotid gland tumour would probably displace both the tumour and the vein in the same direction. Because of the good results found in this study, a prospective clinical evaluation was initiated.

Chapter 5 reports the results of our prospective evaluation regarding pre-operative diagnostics. This study had two aims: to identify the best diagnostic test for differentiating benign from malignant tumours; and to differentiate between superficial and deep lobe tumours. According to this study, Fine Needle Aspiration Cytology was the most accurate

diagnostic test for the discrimination of benign and malignant tumours. The use of pre-operative imaging is not necessary in most cases of parotid gland tumour.

Chapter 6 presents the post-operative results of our patient group. Of the primary benign cases operated on, we had no patients with a recurrence or permanent facial nerve paralysis. Furthermore, using our technique, the incidence of Frey's syndrome was very low. Morbidity was reduced in the group of patients in whom the great auricular nerve was spared.

Chapter 7 discusses the anatomy and surgical techniques for the prevention of Frey's syndrome. Since we have a very low incidence of Frey's syndrome when performing a partial superficial parotidectomy and when suturing the remainder of the parotid gland tissue back towards the sternocleidomastoid muscle after tumour removal, we advocate this technique in primary benign tumours of the superficial lobe.

Chapter 8 describes the strong association found between smoking and the development of Warthin's tumour. In our group of patients, almost all patients with a Warthin's tumour were heavy smokers, in contrast to patients with a pleomorphic adenoma or a control group visiting the audiology department of our outpatient clinic.

Chapter 9 describes a new system for the classification of facial nerve paresis. This is an unweighted, subjective scale based on the anatomic regions of the facial nerve. This chapter also reviews the literature and other frequently used grading systems.

Chapter 10 offers some suggestions for diagnostics and treatment of parotid gland neoplasms in the future; these suggestions are based on the results of our studies.

Samenvatting

In hoofdstuk 1 wordt een algemene beschouwing gegeven over de achterliggende problematiek van dit proefschrift. Hierin komen de huidige literatuur en opvattingen over de diagnostiek en behandeling van gezwellen van de oorspeekselklier (parotis) aan de orde.

In hoofdstuk 2 wordt een anatomische studie beschreven die als doel had het bepalen van de meest bruikbare methode om de aangezichtszenuw te vinden. Hoewel in onze kliniek het tragus kraakbeen, ook wel 'pointer' genoemd, meestal werd gebruikt, is de fissura tympanomastoidea volgens deze studie de meest betrouwbare structuur om de aangezichtszenuw snel te kunnen vinden.

In hoofdstuk 3 wordt een onderzoek beschreven van anatomische lijnen die mogelijk het verloop van de n. facialis in de parotis kunnen voorspellen. Met behulp van dergelijke lijnen zou de ligging van een gezwel in relatie tot de zenuw voorspeld kunnen worden. Zij kennen als belangrijkste anatomische structuur de vena retromandibularis, die een constante relatie heeft met de aangezichtszenuw, zoals gevonden werd tijdens het prepareren van de aangezichtszenuw voor de studie die in hoofdstuk 2 werd beschreven. Deze nieuwe lijnen werden vergeleken met de 'Facial Nerve (FN)-lijn' beschreven door Ariyoshi en Shimahara. De lijn die het meest dorsale gedeelte van de wervel C1 of C2 verbindt met de vena retromandibularis (U-lijn) blijkt een goed alternatief voor de FN-lijn.

In hoofdstuk 4 wordt een retrospectieve studie beschreven waarin de FN-lijn en de U-lijn werden vergeleken. De lijnen werden op zowel CT- als MRI-scans van patiënten met een parotistumor getekend en aan de hand hiervan werd de mogelijke locatie van de tumor voorspeld. Deze voorspelling werd vergeleken met het operatieverslag. Wederom presteerde de U-lijn beter dan de FN-lijn. Dit was reden om de prospectieve evaluatie van hoofdstuk 5 te beginnen.

Hoofdstuk 5 beschrijft een evaluatie van de beeldvorming van parotistumoren met behulp van echografie en MRI. Doel was te bepalen of deze onderzoeken meerwaarde hebben boven lichamelijk onderzoek en cytologie. Uit de resultaten komt naar voren dat voor het vaststellen van de aard van het gezwel, althans het verschil tussen goedaardige en kwaadaardige tumoren, cytologie de meest betrouwbare vorm van preoperatief onderzoek is. Voor het bepalen van de ligging van het gezwel ten opzichte van de aangezichtszenuw is lichamelijk onderzoek vaak net zo accuraat als MRI. Hieruit wordt de conclusie getrokken dat het routinematig aanvragen van een MRI-scan bij parotistumoren overbodig is.

Hoofdstuk 6 houdt zich bezig met de postoperatieve resultaten van parotischirurgie. Hieruit blijkt dat recidief-tumoren en permanente parese van de aangezichtszenuw tegenwoordig

nauwelijks meer worden gezien na primaire chirurgie van goedaardige gezwellen in de parotis. Ook het syndroom van Frey ('gustatory sweating') lijkt grotendeels te kunnen worden voorkomen met de juiste operatietechniek. Het identificeren en sparen van de n. auricularis magnus kan mogelijk de morbiditeit van parotischirurgie in de toekomst nog verder verminderen. Deze werkwijze resulteert in een verlenging van de operatietijd met slechts 10 minuten.

In hoofdstuk 7 wordt gekeken naar de pathofysiologie en de preventie van het syndroom van Frey. Door het huidige beleid om slechts een partiële oppervlakkige parotidectomie te verrichten zal minder vaak de parasympathische innervatie van de speekselklier sneuvelen. Ook wordt, indien mogelijk, het resterende parotis-weefsel met de oppervlakkige musculo-aponeurotische laag teruggehecht naar de m. sternocleidomastoideus. Dit zijn waarschijnlijk de hoofdredenen voor het verminderd voorkomen van het syndroom van Frey.

Hoofdstuk 8 beschrijft de correlatie die gevonden werd tussen rookgedrag en het ontstaan van Warthin-tumoren van de oorspeekselklier. Deze relatie werd vergeleken met het rookgedrag van patiënten met een pleiomorf adenoom van de oorspeekselklier en met patiënten die ons audiologisch centrum bezochten. Het blijkt dat patiënten met een Warthin-tumor bovengemiddeld roken.

In hoofdstuk 9 wordt aandacht geschonken aan de bestaande indelingen van aangezichtszenuwverlammingen, waaronder de op dit moment in de literatuur 'verplichte' House-Brackmann Grading Scale. Ook wordt een nieuw systeem gepresenteerd dat ons inziens een nauwkeuriger classificatie mogelijk maakt, zodat 'follow-up' en resultaten van behandeling makkelijker kunnen worden weergegeven en vergeleken.

In hoofdstuk 10 volgt een beschouwing waarin de consequenties van dit onderzoek voor de toekomst worden beschreven.

Dankwoord

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Curriculum Vitae

De auteur van dit proefschrift werd op 7 mei 1971 geboren te Bennekom (Ede). In 1989 behaalde hij zijn VWO-diploma aan het Christelijk Lyceum Veenendaal. In hetzelfde jaar ging hij rechten studeren aan de Universiteit Utrecht. In 1990 werd het propedeuse-diploma Rechtsgeleerdheid behaald. Van 1990 tot 1997 studeerde hij Geneeskunde aan de Universiteit Utrecht. Van 1 januari tot 1 november 1998 was hij werkzaam als juniordocent bij de vakgroep Functionele Anatomie (prof. dr. B. Hillen). Daarna volgde hij de opleiding tot KNO-arts in het Universitair Medisch Centrum Utrecht (prof. dr. G.J. Hordijk) met een perifere stage in de Gelre ziekenhuizen Apeldoorn (drs. J.B. Antvelink). Sinds 1 december 2004 is hij als KNO-arts verbonden aan het UMCU.
De auteur is getrouwd met Manou Dolmans.

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