Title:

Relationship between muscle dissection method and postoperative muscle atrophy in the lateral suboccipital approach to vestibular schwannoma surgery

Clinical article

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KEY WORDS: vestibular schwannoma, lateral suboccipital approach, muscle dissection, muscle atrophy

RUNNING HEAD: Muscle atrophy in the vestibular schwannoma surgery

ABSTRACT

OBJECT Various techniques are available for occipital skull exposure with muscle dissection as well as different types of skin incision in the lateral suboccipital approach for vestibular schwannoma (VS). The skin incision is generally classified into one of three types: S-shaped, J-shaped, and C-shaped. In each method, the technique used for muscle dissection differs as cut, single layer and multiple layers. This study was performed to determine the relationships between muscle dissection method, skin incision type, and muscle atrophy in the lateral suboccipital approach for VS.

METHODS A total of 53 cases of VS were surgically resected by the authors between 2002 and 2011 at Shinshu University Hospital. Of these, cases with radiographic annual follow-up for more than 3 years after surgery were included in this study and 35 patients were retrospectively evaluated in this study. The numbers of patients were: S-shaped incision, 14; J-shaped incision, 6; and C-shaped incision, 15. Bilateral areas of the skin and occipital muscles were measured, the atrophy rates were calculated and compared among methods.

RESULTS Postoperative muscle atrophy significantly advanced in the second postoperative year, but did not tend to develop further after the third year. The postoperative muscle atrophic ratio in the C-shaped incision group (mean ± SD: 4.0% ± 6.9%) was significantly lower than those in the S-shaped (17.1% ± 9.8%) and J-shaped (17.6% ± 10.0%) incision groups within 2 years after surgery ($P<0.05$).

CONCLUSIONS The C-shaped skin incision with multilayer muscle dissection significantly reduced postoperative muscle atrophy compared with other methods.

KEY WORDS: vestibular schwannoma, lateral suboccipital approach, muscle dissection, muscle atrophy

INTRODUCTION

Vestibular schwannoma (VS) is a relatively common tumor of the cerebellopontine angle, and resection of VS remains the cornerstone of its management. The most commonly used surgical route for VS resection is the lateral suboccipital approach.[9,13,14] The other preferred routes are the translabyrinthine and subtemporal middle fossa approaches.[3] Postoperative muscle atrophy of the skin flap is frequently encountered in the lateral suboccipital approach, and may cause not only cosmetic problems, but also occipital neck pain and headache.[4] However, occipital muscle atrophy after suboccipital craniotomy has not been investigated unlike that associated with frontotemporal craniotomy.[1,6,7,8,10] This study was performed to determine the relationship between muscle dissection with each design of skin incision and muscle atrophy in the lateral suboccipital approach for VS resection.

METHODS

Patient population

This was a retrospective, single-center clinical investigation conducted in a population of 53 patients undergoing surgery for VS via the lateral suboccipital approach by the authors over a 10-year period from 2002 to 2011. Three types of skin incision, i.e., S-shaped, J-shaped, and C-shaped, were applied in lateral suboccipital craniotomy for resection of VS. The method of occipital muscles corresponded to the design of skin incision as division (S-shaped), single-layer dissection (J-shaped) and multilayer dissection (C-shaped), respectively. According to the combination of muscular dissection technique and design of skin incision, patients were classified into three groups in the present study: S, J and C. Exclusion criteria included previous radiotherapy, previous surgery, neurofibromatosis, follow-up at other hospitals, or no serial MRI performed over a 3-year period. The methods of skin incision were divided by period: S-shaped incision (2002 – 2004); J-shaped incision (2004 – 2007); and C-shaped incision (2007 – 2011). Thirty-five patients fulfilled the inclusion criteria described above. Of these 35 patients (16 women and 19 men; mean age 53.8 years, range 31 – 70 years), 14 had the S-shaped incision, 6 had the J-shaped incision, and 15 had the C-shaped incision.

Surgical techniques

Procedures for skin incision with muscle dissection were classified into three patterns as described in the previous section. An S-shaped skin incision was made in an S-shape along the border of the mastoid process. The occipital muscles were divided along the incision line and striped from its bony insertion, then retracted bilaterally to expose the occipital bone. A J-shaped skin incision was made from the midline to mastoid process in the shape of a hockey stick. Occipital muscles were detached from the skull bone in a single layer and the skin flap and muscles were retracted laterally together. A C-shaped skin incision was a semicircular skin incision made in the retroauricular area. The incision was started just above the ear, extended posteriorly to the limit of the planned craniotomy, and curved forward to the hairline of the neck (Fig. 1). The skin was elevated with a subcutaneous tissue flap along with the sternomastoid fascia and reflected anteriorly. The splenius capitis muscle, longissimus muscle, superior oblique muscle, and recti capitis muscles were detached from the nuchal line and the suboccipital bone separately. The splenius capitis muscle was reflected medially, longissimus capitis and superior oblique muscles were reflected laterally, and recti capitis muscles were reflected inferiorly. In this way, the occipital bone was exposed with multilayer muscle dissection. The pericranium in the posterior temporal area was preserved for subsequent closure (Fig. 2) (Video 1).[10]

The lateral suboccipital craniotomy was made sufficiently laterally and high enough to visualize the sigmoid and transverse sinuses. It was larger than 4 cm in diameter in all cases. In addition, the lateral rim of the foramen magnum was removed in cases with large tumors > 3 cm in diameter. After intradural procedures, cranioplasty with autologous bone was routinely performed using titanium plates. Closure technique was slightly different among each methods. Divided muscles with fascia were sutured in each layer in an S-shaped group. Bilateral muscles were sutured midline in the same level without suturing lateral group of muscles in a J-shaped group. Dissected muscles with fascia were sutured with adequate tension and precise direction in each layers in a C-shaped group.

Evaluation of muscle atrophy measurement

All images were obtained with a MAGNETOM 1.5-tesla (Avanto) or 3-tesla (Trio) MR imaging unit (Siemens Healthcare, Erlangen, Germany). The imaging conditions of each device, including TR, TE FOV, and matrix, were almost the same. These MRIs were used for measurement in this study, and axial slice level was photographed consecutively with an MRI reference line consisting of the orbitomeatal line that runs through the external canthus and the center of the external auditory meatus with a slice thickness of 4 – 5 mm. The wound, area of the skin and occipital muscle of the affected side was determined using the digital imaging and communications in medicine (DICOM) viewer. Region of interests (ROIs) were designed around the skin and occipital muscles bilaterally and calculated with DICOM viewer software EV Insite® (version.3.1.1.196; PSP corporation). The ROIs were designed as the area at the level of the occipital condyles in MRI T2-WI axial images, limited anteriorly by an imaging line connecting the central points of both mastoid tips (Fig. 3). Each area was measured three times by two independent raters (T.O. and T.G.) and the mean was adopted. The atrophic ratio of the wound ((contralateral area – ipsilateral area)/(contralateral area) × 100 (%)) was calculated for 1, 2, and > 3 years after surgery and compared between methods.

Statistical analysis

Data are presented as the means ± standard deviation of the mean. The Wilcoxon signed-rank test was used for contingency tables, with $P < 0.05$ considered significant. The Steel–Dwass test was used to compare the three groups with regard to extent of postoperative muscle atrophy, and $P < 0.05$ was considered significant.

RESULTS

Patient demographics

Fourteen patients (40.0%) were treated with an S-shaped skin incision, six patients (17.1%) with a J-shaped skin incision, and 15 (42.9%) with a C-shaped skin incision. The mean ages in these groups were 53.1 (range 31 – 61) years old, 50.7 (range 45 – 58) years old, and 54.7 (range 38 – 70) years old, respectively. The mean body weight of the patients in each group were 56.9 (43.0 – 67.2) kg, 67.3 (54.8 – 77.8) kg, and 60.4 (44.0 – 80.0) kg and the mean tumor length in each group were 22.2 (0 – 48) mm, 35.0 (10 – 50) mm, and 25.1 (8 – 44) mm, respectively. The mean operation times in these groups were 506.9 (392 – 668) minutes, 579.8 (373 – 839) minutes, and 549.5 (375 –

1051) minutes, respectively. The rates of foramen magnum and mastoid air cell opening in the three groups were 0%, 83.3%, and 44.4% and 92.9%, 83.3%, and 55.6%, respectively. There were no significant differences between the three groups with regard to age, body weight, tumor length, or operation time (Table 1).

Correlation between muscle dissection method and muscle atrophy

In the total of 35 patients, the serial atrophic ratios were 7.1%, 11.6%, 12.2% in the first, second, and over third year after surgery. The atrophy progressed significantly until 2 years after surgery and stopped 3 years postoperatively (Fig. 4).

The correlations between the muscle dissection technique with each skin incision type and muscle atrophy were investigated in each group. Atrophy developed significantly in the second year after surgery in comparison with the first year in all groups. There were no significant differences in muscle atrophy between the postoperative second and over third year in any of the groups. The S-shaped, J-shaped, and C-shaped skin incisions caused progressive muscle atrophy for 2 years, with mean atrophic ratios of 17.1%, 17.6%, and 4.0%, respectively. Atrophy did not significantly increase after the second year (Fig. 4). Postoperative muscle atrophy in lateral suboccipital craniotomy progressed for at least 2 years. The atrophy was significantly more severe in the J- and S-shaped skin incision groups than in the C-shaped incision group with the multilayer muscle dissection technique (Fig. 5).

DISCUSSION

Several approaches including the translabyrinthine and subtemporal middle fossa approaches have been proposed for surgery of VS.[3,9,13,14] The lateral suboccipital approach was predominantly utilized by many neurosurgeons, including us.[13,14] Meticulous handling and mobilization of the occipital muscles are essential neurosurgical maneuvers in this approach. In patients undergoing suboccipital craniotomy, detachment of the occipital muscles produces esthetic and functional problems due to atrophy of the muscles.[6] The cosmetic and functional problems that arise from postoperative wound atrophy can be severe. Although atrophy of the temporalis muscle after frontotemporal craniotomy has been reported, postoperative cosmetic problems, including occipital muscle atrophy, in surgery for VS have not been reported previously.[1,6,7,8,10] The cosmetic issues related to muscle atrophy in the lateral suboccipital approach did not attract as much attention as those in frontotemporal craniotomy, because patients are more concerned about facial or lower cranial nerve palsy than muscle atrophy. Recently, however, with high functional preservation rate, there has been increased attention to the issues of postoperative headache, neck pain, and wound atrophy.[4]

The following factors are generally considered as causes of muscle atrophy: 1) direct injury to the muscle fibers due to inappropriate dissection, excessive retraction, or use of a large cuff of muscle for reattachment; 2) muscle ischemia caused by interruption of the primary arterial supply or prolonged retraction; 3) inadequate tension in the reattached muscle; 4) muscle denervation due to direct or indirect injury to the nerve supply.[1,8] Therefore, preserving the integrity of the occipital muscles should be considered mandatory.[6] Based on these factors, small craniotomy and minimal skin incision represent one way to prevent muscle atrophy. However, in VS surgery, craniotomy > 3 cm is necessary for adequate drilling of the posterior lip of the internal auricular canal.[13] A large craniotomy is considered to reduce intradural surgical risks, including unexpected cerebellar swelling, and to permit a multidirectional approach for VS.

Sugita et al. proposed an S-shaped skin incision for suboccipital craniotomy because the lateral suboccipital craniotomy should be made sufficiently lateral to visualize the sigmoid sinus and occasionally the transverse sinus.[12] Kobayashi et al. also proposed an S-shaped skin incision along the medial border of the mastoid process with exposure of the occipital bone with muscle retraction bilaterally.[3] These procedures allow maintenance of muscle tension to prevent atrophy. The conventional S-shaped skin incision is the most commonly employed method due to its simplicity and versatility. However, this method has several limitations. The first of these limitations is that the muscle and skin flap result in a deeper surgical field. This folded myocutaneous flap increases the working distance between the surgeon and the cerebellopontine angle, and interferes with the surgical field, especially in an obese patient with a relatively thick myocutaneous flap.[2] In addition, it is difficult to open the foramen magnum due to the deep and narrow operative field. Another disadvantage is that this procedure sacrifices a number of muscle fibers and the occipital artery. Rarely, occipital ischemia attributed to occipital artery injury may occur, particularly in intensive care units where patients may be kept in the supine position for a long time and they are at risk of occipital sores.[6] Muscle division may lead to increased postoperative discomfort and long-term occipital headaches due to scarring and muscle fibrosis. After this procedure, a certain degree of atrophy and contracture of the occipital muscles occur during healing of the injured muscle fiber.[10]

A J-shaped skin incision is simple with maximum exposure along the occipital bone. This can preserve the subperiosteum widely, preserve innervation and blood supply with minimal muscle fiber dissection. It was reported that en bloc muscle detachment can avoid esthetic and functional damage to the muscle.[5,6] A J-shaped skin incision requires less time, can extend to the cervical area, and can preserve the occipital artery without dividing the muscles. It can also be easily applied to the condylar approach because the operative field can be extended inferiorly.[5] Furthermore, this method can preserve the integrity of the occipital muscles. On the other hand, a long skin incision with exfoliation of the periosteum is necessary, and the semispinalis muscle must be detached from the skull unlike with an S- or C-shaped skin incision. In addition, it is difficult to provide adequate tension to each muscle during wound closure.

Sekhar et al. recommended a C-shaped skin incision with multilayer muscle dissection for removal of VS.[11] This layered elevation of the muscles considerably reduced the occurrence of persistent postoperative headaches due to muscle atrophy. The advantages of the C-shaped skin incision with multilayer muscle dissection are considered to be the lack of muscle division, provision of a wider and shallower operative field, and adequate pedicled muscle flap to cover the opened mastoid air cells. There are, however, several disadvantages of this method, including the more elaborate dissection required through subcutaneous tissues and muscle layers. The technique of multilayer muscle dissection and preservation of the occipital artery is complex and relatively time consuming.

In this study, muscle atrophy progressed by the second year after surgery. A C-shaped skin incision was shown to be superior to other methods from a cosmetic viewpoint. Cosmetic problems will be important factors in choosing the type of skin incision, especially for young or female patients. Furthermore, muscle atrophy may cause uncomfortable headache and neck pain, although these symptoms could not be confirmed in the present study. The surgical scar has a marked influence on patient's quality of life.

In our series, the type of skin incision was changed over years to overcome the disadvantages (deeper surgical field in S-shaped, postoperative cosmetic problems in J-shaped) during the long term follow up. Based on our results, C-shaped incision offered a better result. In our speculation, following three factors of C-shaped skin incision with multilayer muscle dissection are considered as the reason: 1. Lack of muscle division (preservation of muscle fibers), 2. Semispinalis muscle not detaching, 3. Adequate tension and precise direction during muscle closure with cranioplasty. Further studies in larger numbers of patients and with evaluation of longer-term outcomes are required. The influences of opening of the mastoid air cells or foramen magnum, and postoperative cerebrospinal fluid leakage should also be evaluated in future studies.

CONCLUSIONS

Postoperative occipital muscles atrophy might cause patient’s intolerable cosmetic complication. A C-shaped skin incision with multilayer muscle dissection is recommended for surgery for VS from a cosmetic viewpoint. Radiological examination is necessary to identify muscle and skin atrophy for at least 2 years after surgery.

DISCLOSURE

The authors have no personal financial or institutional interests in any of the drugs, materials, or devices discussed in the article. All authors who are members of The Japan Neurosurgical Society (JNS) have registered online self-reported COI Disclosure Statement Forms through the website for JNS members.

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FIGURE LEGENDS

Figure 1. Illustrative diagrams showing three types of skin incision (S-shaped, J-shaped, and C-shaped) for removal of vestibular schwannoma via the lateral suboccipital approach. The technique used for muscle dissection differed for each method. Red lines indicate the design of skin incision.

Figure 2. Intraoperative photograph showing the view of left lateral suboccipital craniotomy with C-shaped skin incision with multilayer muscle dissection (1: sternocleidomastoid muscle, 2: splenius capitis muscle, 3: longissimus capitis and superior oblique muscle, 4: rectus capitis posterior muscle).

Figure 3. Postoperative MRI T2WI axial slice at the occipital condyle level to measure the area by mastoid process, condyle, midline in both ipsilateral (yellow solid line and

area) and contralateral sides (blue interrupted line and area). Atrophy ratio = (contra – ipsi)/contra × 100 (%)

Figure 4. Postoperative muscle atrophy in the lateral suboccipital craniotomy progressed significantly for 2 years in total with all skin incision methods.

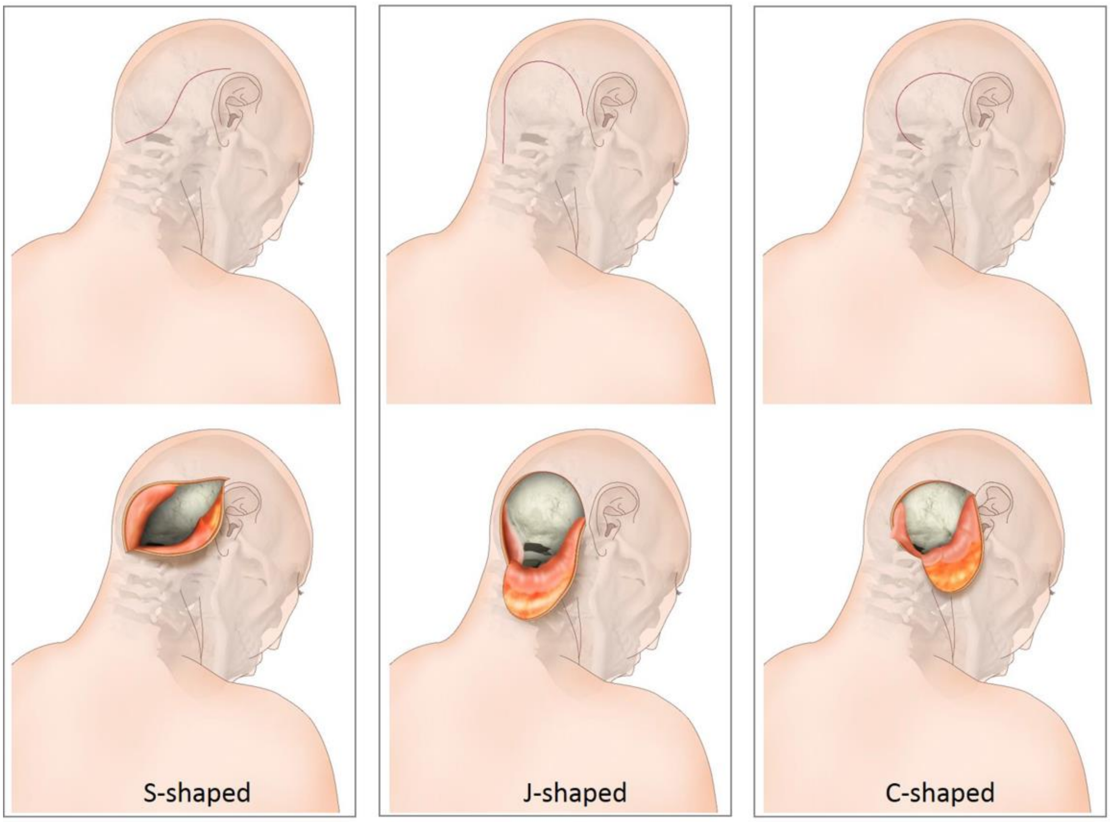
Figure 5. The extents of postoperative muscle atrophy 2 years and 3 years or over after surgery were significantly more severe in the S-shaped and J-shaped skin incision groups than the C-shaped skin incision group with multilayer muscle dissection.

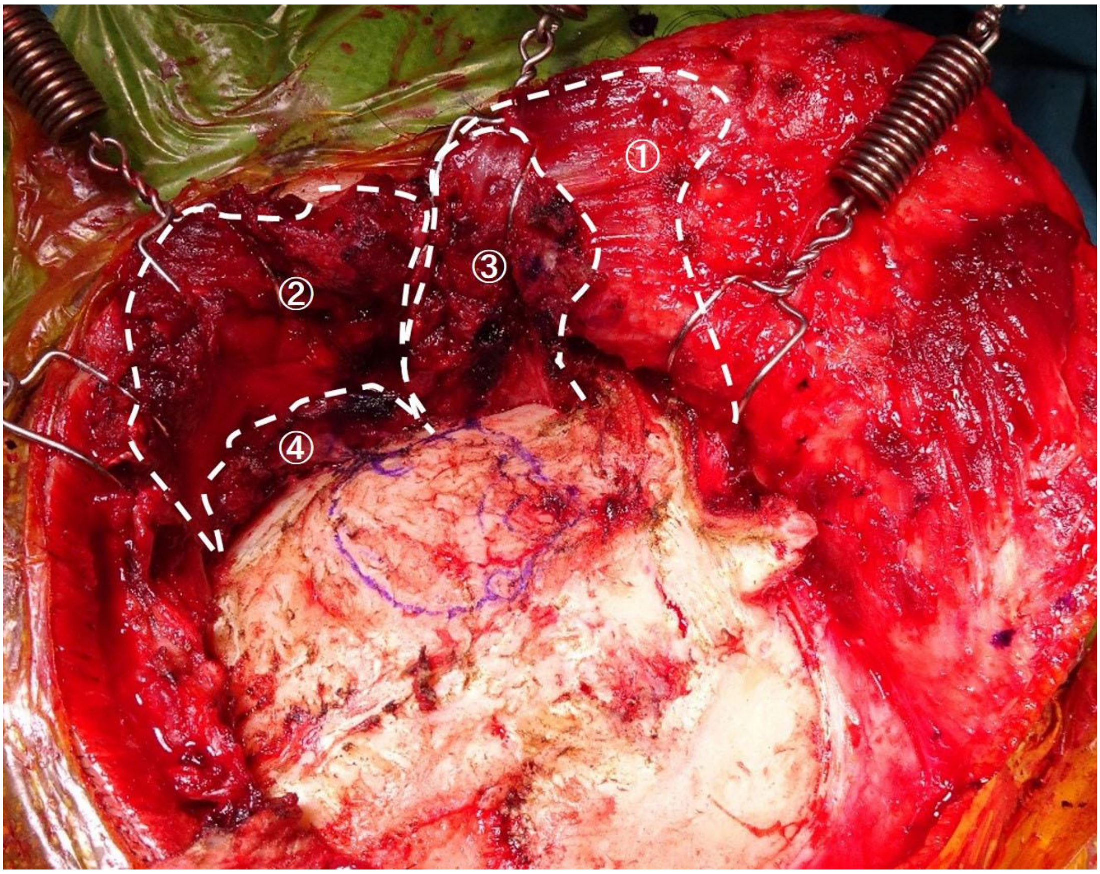
Video 1. The intraoperative video showing the technique of C-shaped skin incision with multilayer muscle dissection for left VS surgery.

Table 1: Details of the patients in each group in the present study

Variable	S-shaped	J-shaped	C-shaped	Value
. of patients (%)	14 (40.0)	6 (17.1)	15 (42.9)	
Sex (M/W)	8/6	5/1	6/9	
ı age (yrs) (Range)	53.1 (31 – 61)	50.7 (45 – 58)	54.7 (38 – 70)	n.s.
ı body weight (kg)	56.9	67.3	60.4	n.s.
ıor size (mm) (Range)	22.2 (0 – 48)	35.0 (10 – 50)	25.1 (8 – 44)	n.s.
ration time (min)	506.9	579.8	549.5	n.s.
magnum opening (%)	0	83.3	40.0	
l air cell opening (%)	92.9	83.3	53.3	

Intracanalicular tumor: Tumor size 0 mm, n.s.: not significant


S-shaped
J-shaped
C-shaped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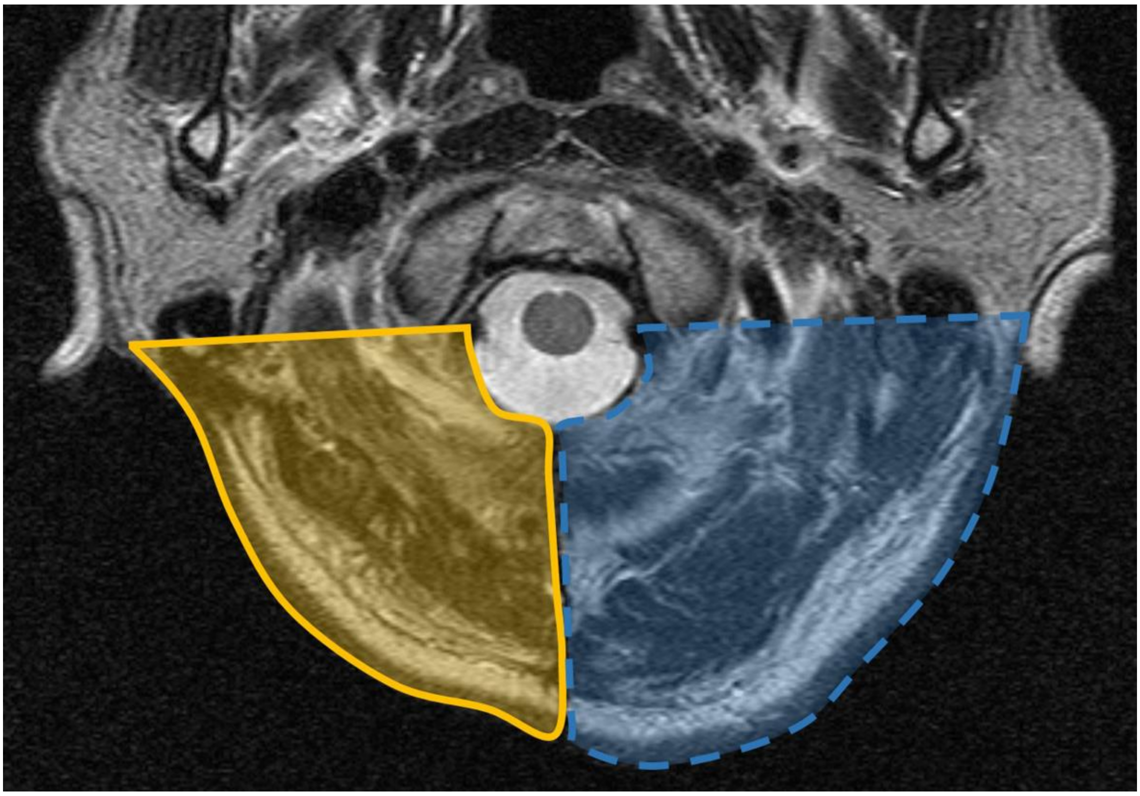
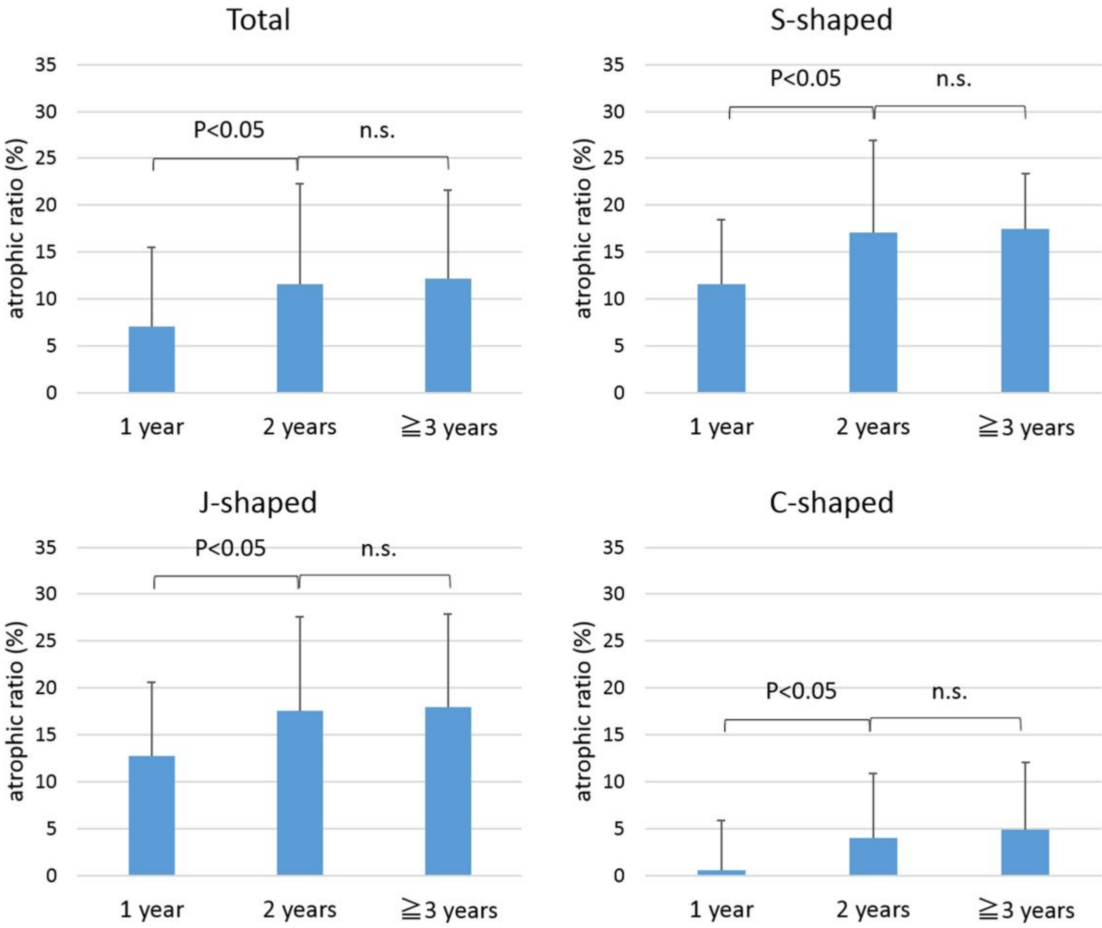
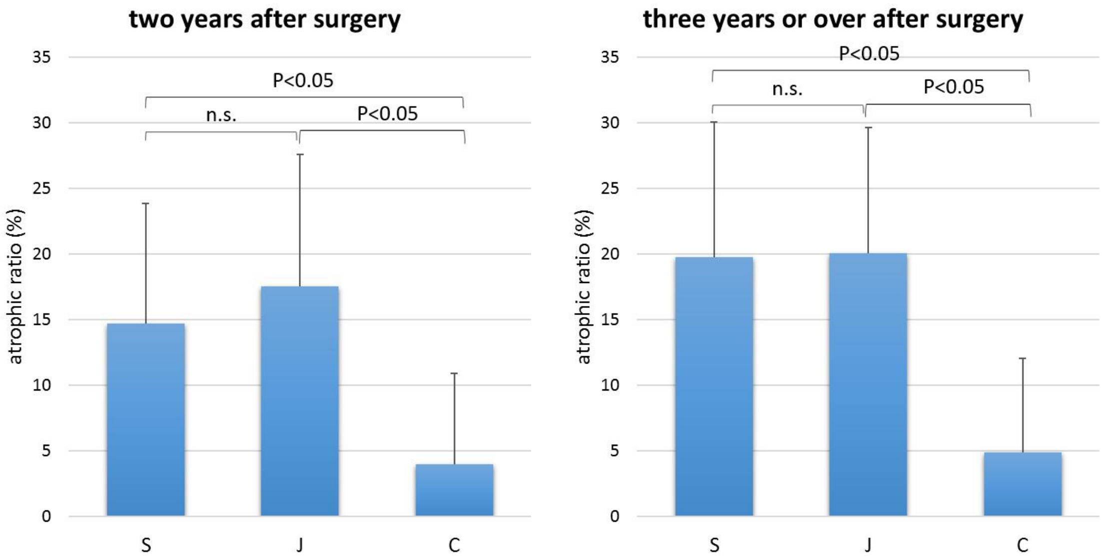



Total
S-shaped
J-shaped
C-shaped
atrophic ratio (%)
P<0.05
n.s.
0
5
10
15
20
25
30
35
1 year
2 years
≧3 years


two years after surgery
three years or over after surgery
atrophic ratio (%)
35
30
25
20
15
10
5
0
P<0.05
n.s.
P<0.05
S
J
C