Submandibular approach to the C2–3 disc level: microsurgical anatomy with clinical application

Laboratory investigation

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Object. Approaching the C2–3 disc level is challenging because of its location behind the mandible and the vital neurovascular structures overlying the area. The purpose of this study was to illustrate in a stepwise fashion the microsurgical anatomy of the submandibular approach to the C2–3 disc.

Methods. Ten adult formalin-fixed cadaveric specimens (20 sides) were studied. Particular attention was paid to the structures limiting the exposure. The authors measured the distance between the inferior border of the mandible and the marginal mandibular branch of the facial nerve running inferior to the mandible, the distance between the horizontal segment of the hypoglossal nerve and the hyoid bone, and the distance between the horizontal segment of the hypoglossal nerve and the mandible. They compared the location of the superior laryngeal nerve with regard to the submandibular and the standard Smith-Robinson approaches. A clinical case illustrating the usefulness of the surgical technique in this region is presented.

Results. The mean distance between the inferior border of the mandible and the lowest point of the marginal mandibular branch of the facial nerve was 6.7 ± 1.69 mm. The hypoglossal nerve’s mean distance above the hyoid bone was 8.4 ± 1.78 mm and below the mandible was 19.6 ± 6.39 mm. The internal branch of the superior laryngeal nerve, with respect to the cervical spine, always entered the thyrohyoid membrane just inferior to the C-3 vertebral body. The superior laryngeal nerve was found to be an impediment to approaching the C2–3 disc through the standard Smith-Robinson approach.

Conclusions. The submandibular approach provides excellent exposure, with a perpendicular view of the C2–3 disc level. This approach is one of the options to be considered when dealing with high cervical pathologies.

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KEY WORDS • submandibular triangle • parapharyngeal quadrilateral space • C2–3 disc • surgical approach • microsurgical anatomy

SURGICAL approaches to the C2–3 disc level are challenging because of its location behind the mandible and the vital neurovascular structures overlying the area. Despite the many techniques described in the literature, there is still a lack of consensus concerning the optimum approach to the C2–3 disc level.

The standard Smith-Robinson anterior cervical approach, used to approach the mid and lower cervical spine, has disadvantages when approaching the C2–3 level, because of the location of the SLN, the need for excessive retraction, and the inferior to superior oblique angle of view provided by this approach.

The submandibular approach, also referred to as the anterolateral high cervical approach to the craniocervical junction, exposes the area above the hyoid bone and medial to the ECA-ICA complex.

It provides excellent exposure, with a perpendicular view of the C2–3 disc level, allowing an anterior decompression and fusion. However, several risks can be associated with this approach, such as injury to the hypoglossal and SLNs, as well as injury to the marginal mandibular branch of the facial nerve.

The purpose of this article is to present the detailed anatomy of the submandibular approach as a guide to increase the safety of the approach to this area. For this purpose, stepwise dissection of the submandibular triangle and a clinical case illustrating the usefulness of the surgical technique in this region are presented.

Methods

Cadaveric Study

The submandibular regions of 10 formalin-fixed, cadaveric heads and necks (20 sides) were studied. The
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vessels were injected with colored silicone. Dissection of the submandibular region was performed with the aid of a surgical microscope at ×3–40. Particular attention was paid to the structures limiting the exposure. We measured the distance between the inferior border of the mandible and the lowest point of the marginal mandibular branch of the facial nerve running inferiorly to the mandible, the distance between the lowest point of the horizontal segment of the hypoglossal nerve and the hyoid bone, and the distance between the lowest point of the horizontal segment of the hypoglossal nerve and the mandibular bone. We also compared the location of the SLN with regard to the submandibular and the standard Smith-Robinson approaches.

Results

The mean distance between the inferior border of the mandible and the lowest point of the marginal mandibular branch of the facial nerve was 6.7 ± 1.69 mm. The hypoglossal nerve’s mean distance above the hyoid bone was 8.4 ± 1.78 mm. The mean distance between the lowest point of the horizontal segment of the hypoglossal nerve and the mandibular bone was 19.6 ± 6.39 mm (Table 1). With respect to the cervical spine, the ISLN always entered the thyrohyoid membrane just inferior to the C-3 VB (see Fig. 5B and C). The SLN was found to be an impediment to approaching the C2–3 disc through the standard Smith-Robinson approach in every specimen (see Fig. 5D).

Anatomical Considerations

The head is extended 15° and rotated 45° contralateral to the side of the surgical approach displacing the mandible superiorly, out of the surgeon’s line of sight (Fig. 1). Head rotation is necessary to provide access through the superficial structures of the upper neck. However, the main rotation occurs at the C1–2 level and preserves the neutral position at C2–3, allowing for a perpendicular approach to the level.44 The side of the surgical approach is determined based on the disc-osteophyte location and/or preoperative lower CN deficit. A lateral herniation is approached contralateral to the side of the herniation, which provides a better angle of exposure to address the most lateral portions of such a lesion, whereas an ipsilateral approach is used if a preoperative CN deficit exists. The facial and the hypoglossal nerves are monitored intraoperatively.

In our specimens, the maximum distance between the inferior border of the mandible and the lowest point of the marginal mandibular branch of the facial nerve was 10.4 mm (Table 1). The incision in the submandibular region should be made ≥ 2 cm below and parallel to the inferior border of the mandible to avoid injury to the marginal-mandibular branch lying within the investing fascia posterior to the facial vein. Anterior to the facial vein, the nerve runs within

TABLE 1: Measurements of anatomical structures in 10 cadavers*

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<th>Specimen No.</th>
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<th>Mandible-CN VII</th>
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* All parameters and distances are in millimeters.
Fig. 2. A: Photograph showing the anatomical dissection, right side. The skin and platysma muscle have been reflected forward. The facial nerve enters the posteromedial surface of the parotid gland, crosses superficially to the ECA and the retromandibular vein, and divides into a number of branches that emerge separately from the gland and pass to supply the muscles of the facial expression. The 5 major branches of the facial nerve are the temporal (Temp. Br.), zygomatic (Zyg. Br.), buccal (bucc. br.), marginal mandibular (m. m. br.), and cervical (cerv. br.). The mean distance between the inferior border of the mandible and the lowest point of the marginal mandibular branch of the facial nerve was 6.7 ± 1.69 mm (arrow). The anterior facial vein, after receiving tributaries from the region of the face, descends at the anterior border of the masseter muscle and extends posteriorly through the submandibular triangle to join the anterior division of the posterior facial vein. This union forms the common facial vein. There is commonly a large venous network that covers the submandibular triangle. This can be transected without any clinical consequences to expose the submandibular (Submand) gland. B: Magnified view of panel A. The investing fascia and the platysma have been removed posterior to the facial vein. The segment of the marginal mandibular branch of the facial nerve that courses anterior to the facial vein has been partially exposed. The marginal mandibular branch of the facial nerve posterior to the facial vein runs within the investing layer (a). The marginal mandibular branch anterior to the facial vessels typically runs within the muscular fibers of the platysma (b). C: Artist’s drawing showing the relationship between the marginal mandibular branch of the facial nerve and the platysma. The marginal mandibular branch supplies the muscles of facial expression that pull and close the angle of the mouth and pull the lower lip downward (depressorii labii inferioris and depressorii anguli oris). EJV = external jugular vein; Gr. Aur. N. = great auricular nerve; M. = muscle.
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the muscular fibers of the platysma. Therefore, there is no danger of injuring the nerve if the dissection is kept deep to the investing fascia (Fig. 2). The platysma is reflected, thus exposing the submandibular gland (Fig. 3A). Some authors have suggested resecting the submandibular gland, but in our opinion this is not necessary for the exposure of the C2–3 level. The gland is elevated and displaced with a self-retaining retractor. A fascial sling tethers the tendon of the digastric muscle to the greater horn of the hyoid bone. By transecting this fascial sling along the course of the tendon, the tendon is freed and retracted rostrally toward the mandible thus exposing the hypoglossal nerve (Fig. 3C). The posterior belly of the digastric muscle is a reliable guide to identify the hypoglossal nerve as it passes deep and inferior to the muscle (Fig. 3B). An alternative method of locating CN XII is to use the carotid bifurcation as a landmark. Dissecting from the carotid bifurcation in a rostral direction, one will find the hypoglossal nerve at a mean distance of 15 mm superior to the bifurcation and, in a minority of cases, it may lie on the bifurcation itself. The hypoglossal nerve is gently dissected along its course and retracted superiorly. The carotid artery is retracted laterally, and the pharyngeal constrictor muscles are retracted medially. This maneuver opens the retropharyngeal space (Fig. 4A). There is often a vein draining the retropharyngeal space attached to the common facial vein that can be used as a guide to the retropharyngeal space (Fig. 3B). Attention must be paid not
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![Image](A: The intermediate tendon of the digastric muscle and the hypoglossal nerve have been retracted superiorly. The lingual artery is the second of the 3 anterior branches of the ECA, it is given off just below the origin of the facial artery in the carotid triangle, frequently as a common trunk with the latter. It extends forward near the tip of the greater horn of the hyoid bone. It then passes deep to the hyoglossus muscle to give off its terminal branches. The retropharyngeal space is located behind the pharyngeal constrictor muscles and medial to the carotid artery. It is bounded anteriorly by the buccopharyngeal fascia and posteriorly by the alar fascia. B: There is a safe entry zone, the parapharyngeal quadrilateral space that permits a safe exposure of the C-2 body and C2–3 disc without placing neural structures at risk. The anatomical borders of the quadrilateral space are as follows: superiorly the hypoglossal nerve gently retracted upward; inferiorly the ISLN and the hyoid bone; medially an ideal line paralleling the stylopharyngeus muscle down to the hyoid bone, and laterally the ECA-ICA complex; the lingual artery often crosses the quadrilateral space and can be divided to expand the corridor to the region. Retroph. = retropharyngeal; Sup.lar.n. = SLN.)

![Image](to injure the glossopharyngeal nerve that lies behind the stylopharyngeus muscle (Fig. 3C). There is a safe entry zone that we refer to as the parapharyngeal quadrilateral space that permits a safe exposure of the C-2 VB and the C2–3 disc level without damaging any neural structures. The anatomical borders of the quadrilateral space are as follows: superiorly the hypoglossal nerve gently retracted upward; inferiorly the ISLN and the hyoid bone; medially an ideal line paralleling the stylopharyngeus muscle down to the hyoid bone, and laterally the ECA-ICA complex. The lingual artery often crosses the quadrilateral space and can be divided to expand the corridor to the region (Fig. 4B). With respect to the cervical spine, the ISLN enters the thyrohyoid membrane just inferior to the C-3 VB (Fig. 5B). The internal branch of the SLN can be located using the superior laryngeal artery and the greater horn of the hyoid bone as landmarks. Once the nerve is located on the thyrohyoid membrane, it can be followed proximally. With wide release of the cervical fascial planes, the ISLN can be exposed and mobilized with minimal retraction, thereby minimizing injury and functional impairment. Attention must be paid while dissecting near the greater horn of the hyoid bone where the ISLN is very superficial. The trunk of the SLN is also at risk for injury during dissection around the carotid bifurcation. As it descends medially toward the thyrohyoid membrane, the SLN lies in the paratracheal fascia covering the longus colli muscle. For this reason, great care must be taken not to inadvertently damage the nerve during dissection of the fascia deep to the carotid arteries. The SLN is prone to injury especially during the placement of self-retaining retractor blades. To avoid direct injury to the nerve, it is important that the retractor blades are secured under the medial edge of the longus colli muscle to avoid malpositioning laterally over the muscles. The superior laryngeal artery provides blood to the nerve and follows the internal branch of the SLN closely. Excessive retraction can cause small hemorrhages from this artery, and in the process of securing hemostasis, coagulation of such bleeding could inadvertently damage the ISLN or cause ischemic injury to the nerve.29

The anterior surface of C-2 and C-3 is then exposed in the typical manner, by elevating the longus colli muscles medial to lateral (Fig. 6). At this point, the technique of discectomy and instrumentation is identical to that of the standard Smith-Robinson approach.

**Illustrative Case**

**History and Examination.** This 49-year-old man presented with progressive weakness and numbness involving the left upper and lower extremities. He had undergone 2 previous anterior cervical surgeries at an outside facility. His initial surgery was an anterior cervical discectomy and fusion with plating at the C4–5 and C5–6 levels via a right-sided standard Smith-Robinson approach. He subsequently developed adjacent segment disease and underwent a C3–4 anterior cervical discectomy and fusion with plating via a left-sided standard Smith-Robinson approach. Physical examination revealed...
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Figure 5. Anatomical photographs. A: Cadaveric dissection of the right cervical region. The masseter and platysma muscles have been removed thus exposing the mandible and the submandibular gland. The hyoid bone has been exposed by detaching the overlying fascia. The SLN originates from the vagus nerve within the carotid sheath at the level of the C1–2 vertebra and descends medially toward the thyrohyoid membrane. The SLN passes deep to the ICA, it has a very short course (mean 15 mm, range 3–20 mm) before it divides deep to the carotid artery bifurcation into an internal branch (ISLN), primarily a sensory branch, and an external branch, primarily a motor branch. The external branch of the SLN descends toward the cricothyroid muscle. B: The lingual artery has been divided and reflected laterally. The longus colli muscles have been dissected in a medial to lateral fashion thus exposing the anterior surface of the cervical spine. With respect to the cervical spine, the ISLN enters the thyrohyoid membrane inferior to the C-3 VB, at the level of the C3–4 intervertebral disc space. The ISLN traverses at an oblique angle just inferior to the greater horn of the hyoid bone, and approaches the thyrohyoid membrane accompanied by the superior laryngeal artery, a branch of the superior thyroid artery. The internal branch of the SLN can be identified by use of the superior laryngeal artery and the greater horn of the hyoid bone, as landmarks. Once the nerve is located on the thyrohyoid membrane, it can be followed proximally. C: The arrow indicates the trajectory of the submandibular approach above the SLN. No retraction of the nerve is required to access the C2–3 interspace. D: The arrow indicates the trajectory of the standard Smith-Robinson approach. Significant upward retraction of the SLN is required to access the C2–3 interspace. sup. thyr. a. = superior thyroid artery.
decreased left upper-extremity strength (4-/5) in grip and biceps, decreased subjective sensation in the left upper and lower extremities, increased reflexes in the upper extremities, and a Hoffman sign bilaterally. In addition, he had a positive Lhermitte sign with neck extension and axial compression.

Preoperative MR imaging and CT scanning showed a previous anterior cervical fusion from C-3 to C-6. The MR images demonstrated a disc-osteophyte at the C2–3 level with left paramedian spinal cord compression (Fig. 7A and B).

Operation. A right-sided submandibular approach was performed to expose the C2–3 disc level. The approach provided a wide, perpendicular exposure of the C2–3 interspace that allowed for removal of the compressive disc-osteophyte under direct microscopic view down to the level of the thecal sac. The approach provided enough exposure to instrument the level without the need for excessive retraction of the soft tissues (Fig. 8).

Postoperative Course. The postoperative course was uneventful, characterized by no CN deficit, and immediate extubation after the surgical procedure. Transient dysphagia due to local edema regressed on postoperative Day 2. At the 3-month follow-up, the patient’s neurological symptoms had largely resolved. Postoperative MR imaging demonstrated an excellent decompression at the C2–3 interspace (Fig. 7C and D).

Discussion

Anterior surgery for degenerative disc disease at the C2–3 level is rare. The literature contains only 12 publications reporting 23 cases of C2–3 disc herniations.1–5,7,11,13,20,22,31,32,40 Most cervical disc herniations occur at C5–6 and C6–7 because these levels are more mobile and carry a greater load during cervical movement.16,30 High cervical disc herniations tend to occur in older people and are associated with previous subaxial arthrodesis.1,6,11,13,20,32 However, given the increasing numbers of patients undergoing subaxial fusions, C2–3 pathology could become more common in the future.

Despite the many techniques described in the literature, there is still a lack of consensus concerning the optimum approach to the C2–3 level. Previously described anterior approaches to C2–3 include the transoral approach with or without mandible and tongue splitting,5,7,9,18,19,28,33,43
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and tongue splitting provides an excellent exposure of the craniovertebral junction. However, the approach is associated with high rates of surgical morbidity. Moreover, the standard transoral approach exposes the region from the lower one-third of the clivus to the middle of the C-2 VB. Therefore, it is necessary to perform a mandibulotomy to increase the exposed region from the midclivus to the C2–3 interspace.45 Another disadvantage of the transoral approach is oropharynx contamination, when instrumentation is required.

The anterolateral extradural approach provides good exposure of the lateral aspect of the upper cervical spine and facilitates decompression of the spinal cord and ipsilateral nerve root. The main disadvantages of the anterolateral approach include dissection of the VA and potential damage to the spinal accessory nerve. In addition, for optimal exposure and VA dissection, the C-2 nerve root must be sectioned.2,3

The standard Smith-Robinson anterior cervical approach is commonly used for exposure of the anterior surface of the mid and lower cervical spine. It provides an excellent and perpendicular view of the anterior cervical spine from the C-3 level down to the C-7 level. The limitations of the standard Smith-Robinson approach above the level of the C-3 VB are the difficulty in obtaining a perpendicular view of the C2–3 disc at the level of the thecal sac, the need for excessive retraction, and the problems with instrumentation and placing a graft at an oblique, superiorly projecting angle. The main anatomical structure limiting the exposure of the C2–3 disc level through the standard Smith-Robinson approach is the internal branch of the SLN (Fig. 5D). In our study, the ISLN was found to be an impediment to approaching the C2–3 disc through the standard Smith-Robinson approach in 100% of cases (20 cadaveric sides). The ISLN entered the thyrohyoid membrane inferior to the C-3 VB in every specimen (Fig. 5B). In a retrospective review of the standard anterior cervical approach, at all cervical levels, permanent or temporary injury to the SLN or recurrent laryngeal nerve was reported in > 16% of cases.4 When adding the extra retraction necessary to access the C2–3 interspace, one would expect these rates to be even higher.

The submandibular approach takes advantage of a natural corridor above the SLN and below the hypoglossal nerve. With wide dissection of the fascial planes, injury to these nerves can be avoided. The approach provides direct, perpendicular and wide exposure of the C2–3 disc. The approach provided enough exposure to instrument the level without the need for excessive retraction of the soft tissues.

Conclusions

Disc herniations at the C2–3 level are extremely rare. Various surgical techniques have been described in the

Fig. 8. A: Intraoperative fluoroscopy showing the perpendicular trajectory to the C2–3 disc level through the submandibular approach. B: The submandibular approach also provides access to the entire anterior surface of C-2 up to the C-1 anterior tubercle. C: Intraoperative photograph showing positioning of the intervertebral cage at C2–3 disc level. This approach provides direct, perpendicular and wide exposure of the C2–3 disc. The approach provided enough exposure to instrument the level without the need for excessive retraction of the soft tissues.

citing the anterolateral extradural approach,2,3,14,15,17,30,40,42 and the standard Smith-Robinson anterior cervical approach.3,21

The transoral approach with or without mandible
literature to treat C2–3 disc herniations, but each has its restrictions and limitations. Knowledge of the microsurgical anatomy of the submandibular approach will help surgeons to perform safe surgery and give to the neurosurgical community a valid alternative to the commonly used approaches when dealing with high cervical pathology.

Disclaimer

The authors report no conflicts of interest concerning the materials or methods used in this study or the findings specified in this paper.

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References

38. Stephens RE, Wendel KH, Addington WR: Anatomy of the...