Skull Base Dural Closure Using a Modified Nonpenetrating Clip Device via an Endoscopic Endonasal Approach: Technical Note

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Abstract

Skull base reconstruction after an endoscopic endonasal approach into the cerebrospinal fluid (CSF) space is always challenging. Various reconstructive methods are available, but no standard technique is established. This report describes the endoscopic skull base dural closure using a modified nonpenetrating clip device with shaft length of 15 cm. Six patients with an intra-suprasellar or suprasellar tumor who underwent extended endoscopic endonasal transsphenoidal surgery were targeted. For closure of the skull base dural defect after tumor removal, fascia lata was first placed as an inlay graft and was subsequently fixed with the dura using a modified nonpenetrating clip device. No CSF leakage from the closed dura with an inlay fascia lata fixed with clips was confirmed by the Valsalva maneuver. To complete skull base reconstruction, fascia lata was then positioned as an overlay graft and covered with vascularized pedicled nasoseptal flaps. Five of six patients experienced no CSF rhinorrhea postoperatively. The modified nonpenetrating clip device may achieve effective dural closure in the deep and narrow nasal cavity. We introduce this clip device technique as one of the endoscopic skull base dural closure methods.

Keywords: endoscopic skull base surgery, extended endoscopic endonasal transsphenoidal surgery, nonpenetrating titanium clip, skull base dural closure

Introduction

Reconstruction of the skull base defect is critical to prevent postoperative complications such as cerebrospinal fluid (CSF) rhinorrhea in endoscopic skull base surgery or extended endoscopic endonasal transsphenoidal surgery. The major three skull base reconstructive methods, in addition to filling the dead space of the sella turcica, are as follows: (1) dural closure with various patch grafts including fascia sutured in a watertight fashion,1) (2) covering the skull base defect with the vascularized pedicled nasoseptal flap,2–4) and (3) multilayered repair of the skull base defect using free autologous grafts.5,6) Combinations of (1), (2), and (3) are widely used, but all these procedures require experience to master. In particular, the needle suturing technique for endoscopic dural closure is difficult to perform consistently in deep and narrow nasal passages. Closure of the skull base dural defect was reported to be achieved using a technique with a nonpenetrating titanium clip device, the AnastoClip Vessel Closure System (AnastoClip VCS; LeMaitre Vascular, Burlington, MA, USA), which was developed for vascular repair.7) The shaft length of the clip device was lengthened from 8 to 15 cm in 2015. The long shaft model of AnastoClip VCS (= modified AnastoClip VCS) (Fig. 1) is expected to be more valuable than previously reported for endoscopic endonasal surgery.

Materials and Methods

We used the modified AnastoClip VCS for six patients with an intra-suprasellar or suprasellar tumor who underwent extended endoscopic endonasal transsphenoidal surgery at Nippon Medical School Hospital. There were four females and two males whose ages ranged from 39 to 67 years. The modified AnastoClip VCS was utilized for dural closure in the skull base reconstruction after tumor removal.
Skull base reconstruction using a modified nonpenetrating clip device

We always prepare the vascularized pedicled nasoseptal flaps and fascia lata free graft and select the binostril transseptal approach in endoscopic skull base surgery or extended endoscopic endonasal transsphenoidal surgery. Unlike the mononostril approach with restricted manipulation due to interference between the endoscope and the modified AnastoClip VCS, the binostril work allows the surgeon to manipulate flexibly the modified AnastoClip VCS.

In the first step of skull base reconstruction following tumor removal, fascia lata was inlaid at the skull base dural defect while stretching and was subsequently fixed with the dura using the modified AnastoClip VCS. As a technical point, we consider that the dura requires an ample margin with wide resection of bone to permit the head of the modified AnastoClip VCS to approach sufficiently and the graft material size should also be correspondingly large enough. When the dura was under tension or had an insufficient margin, the clips were applied while overlapping the dural edge and the graft material drawn toward the dura. No leakage of CSF from the closed dura with an inlay fascia lata fixed with clips was then confirmed by the Valsalva maneuver. In the next step, fascia lata was overlaid on the entire skull base defect. The final step was to cover the surgical field with the vascularized pedicled nasoseptal flaps. Fibrin glue coating was conducted in each step.

Illustrative Case

Case 1: A 39-year-old woman with a past history of IgA nephropathy suffered from decreased visual acuity and bitemporal hemianopia. Brain imaging revealed an intra-suprasellar tumor of 3.9 cm maximum size with cystic and densely calcified solid components, extending superiorly into the third ventricle (Figs. 2a and 2b). The patient underwent removal of the tumor via an extended endoscopic endonasal transsphenoidal approach with harvesting of vascularized pedicled nasoseptal flaps. The sellar floor expanding to the anterior skull base was opened. Since the tumor was located behind the pituitary gland and stalk, the retrochiasmatic space was accessed by mobilizing the pituitary gland with partial removal. Total removal of the tumor was achieved by repeated meticulous dissection. In the skull base reconstruction, fascia lata was first inlaid at the skull base dural defect while stretching and was subsequently fixed with the dura using the extra-large-sized modified AnastoClip VCS (Fig. 3a–3c). Venous oozing caused by clip application was easily controlled with absorbable gelatin sponge (Gelfoam, Pharmacia & Upjohn, Kalamazoo, MI, USA) (Figs. 3d and 3e). A total of eight clips were applied in 8 minutes and 18 seconds (Fig. 3f). No leakage of CSF was detectable during the Valsalva maneuver following the dural closure. Next, fascia lata was overlaid on the entire skull base defect. The surgical field was finally covered with the vascularized pedicled nasoseptal flaps. Each step was followed by fibrin glue coating. Supplementary Video 1 demonstrates the skull base reconstruction using the modified AnastoClip VCS of case 1.
The patient was discharged on foot with steady recovery of visual impairment and newly appeared mild diabetes insipidus. Postoperative brain imaging exhibited total removal of the tumor (Figs. 2c and 2d). The applied clips were visualized without marked metallic artifacts in postoperative computed tomography scan and magnetic resonance imaging and had little effect on the quality of postoperative brain images (Fig. 4). Histopathological examination indicated adamantinomatous craniopharyngioma.

Results
Clinical characteristics of all patients are summarized in Supplementary Table 1 (available online). Diagnosis of our cases included craniopharyngioma in five patients and meningioma in one patient. All patients underwent total removal of the tumor due to extended endoscopic endonasal transsphenoidal surgery and were discharged ambulatory. The average dural closure time per clip application ranged from 15.3 seconds to 1 minute 52.6 seconds. No CSF rhinorrhea
was noticed in five cases in postoperative follow-up. However, only one of six patients who treated was suspected of having a serous nasal discharge despite no pneumocephalus. Although no obvious CSF leakage point was observed in the intraoperative finding, the reconstructed skull base was repaired using a fascia lata and fibrin glue resulting in disappearance of nasal discharge.

Discussion

CSF rhinorrhea following endoscopic skull base surgery may be caused by migration of patch grafts, development of CSF fistula, and pulse effect of CSF pressure.\(^1\)\(^,\)\(^8\) Graft migration can be prevented by fixing the patch graft rather than simply spreading it. We regard fixing the patch graft securely as a very important step to create a solid barrier for CSF fistula and pulse pressure in addition to the multi-layered repair including coverage with the vascularized pedicled nasoseptal flap. Endoscopic dural closure by needle suturing is commonly accepted in Japan, but is not easy to perform. Variations in graft materials, needle sizes, needle holder types, and techniques adopted in medical institutions as well as differences in operator proficiency may hinder familiarity.

The modified AnastoClip VCS, having small, medium, large, and extra-large sizes, is indicated for vascular reconstructive surgery and also approved for dural closure except for the small size. The intrinsic benefit of the AnastoClip VCS is to avoid the risks of hole creation in the dura and grafts and neurovascular injuries because of the nonpenetrating nature of the clip. Since this clip does not penetrate tissue, we could easily stop blood oozing caused by clip application but should always pay great attention to arterial injury.

The modified AnastoClip VCS has a shaft length of 15 cm. The depth between the nasal vestibule and anterior sellar wall is described in the range of 6.22–9.08 cm.\(^9\) Therefore, the modified AnastoClip...

Fig. 3 Intraoperative images of case 1. (a–c) Dural closure using the modified AnastoClip Vessel Closure System after placing fascia lata as an inlay graft at the skull base dural defect. (d, e) Controlling venous oozing due to clip application with absorbable gelatin sponge (yellow circle). (f) Closure of the skull base dural defect with an inlay facia lata fixed with eight nonpenetrating clips taking 8 minutes and 18 seconds. (Supplementary movie is available online)
VCS is definitely more comfortably manipulated than the conventional one with a shaft length of 8 cm reported in the past.\(^7\) Furthermore, the bottom of the modified AnastoClip VCS can be rotated through 360 degrees, which enables fine adjustment of the approach angle. The moment of clip application could be exactly controlled by the adequate shaft length, flexible approach, and slightly curved tip (Fig. 1).

The closure time of the skull base dural defect by needle suturing with fascia or composite graft consisting of fascia and artificial dura was reported to be 93.5 ± 19.1 minutes and 45.9 ± 12.4 minutes, respectively.\(^1\) In our cases, the average dural closure time per clip application ranged from 15.3 seconds to 1 minute 52.6 seconds was obtained by the method using the modified AnastoClip VCS, which may indicate to be typically shorter.

The clip of the AnastoClip VCS is made of pure titanium with low iron content, which offers little metallic clip artifacts affecting postoperative assessment in computed tomography scan and/or magnetic resonance imaging and also resistant to infection. The applied clips are covered by overlay fascia lata and vascularized pedicled nasoseptal flaps so that the problem of clip migration may hardly occur. However, we should be careful not to lose the clips. In addition, when the applied clip is unstable or improperly positioned, we can remove it using a dedicated clip remover for the modified AnastoClip VCS.

Fig. 4 Postoperative brain imaging of case 1. Postoperative axial computed tomography scan (a, b) and magnetic resonance imaging (c) showing the applied clips without marked metallic artifact (green circle). (d) Postoperative coronal magnetic resonance imaging demonstrating that the applied clips had little effect on postoperative assessment.
The modified AnastoClip VCS costs $999 per set; hence, careful consideration of cost-effectiveness is necessary in deciding to use it. In the future, accumulation of cases without CSF leakage during the Valsalva maneuver in which an inlay fascia lata and the dura are securely fixed using the modified AnastoClip VCS may lead to evidence that nasoseptal flap coverage with the risk of nasal discomfort is not constantly required. We believe that this clip device technique can safely replace the needle suturing technique when having suitable conditions such as ample dural margins and allow us to save surgical time greatly and to reduce surgeon fatigue.

Conclusion

Secure dural closure is essential for skull base reconstruction in endoscopic endonasal surgery. The modified AnastoClip VCS may have advantages for endoscopic dural closure in terms of convenience and procedure stability. We intend to clarify the validity and appropriate indication of this clip device technique in endoscopic skull base reconstruction by accumulating cases.

Ethical Approval

All procedures performed in this report were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Declaration of Helsinki and its later amendments or comparable ethical standards.

Informed Consent

Informed consent was obtained from all individual participants included in this report.

Conflicts of Interest Disclosure

The authors declare that they have no conflict of interest.

References

1) Kitano M, Taneda M: Subdural patch graft technique for watertight closure of large dural defects in extended transsphenoidal surgery. *Neurosurgery* 54: 653–660; discussion 660–661, 2004
2) Hadad G, Bassagasteguy L, Carrau RL, et al.: A novel reconstructive technique after endoscopic expanded endonasal approaches: vascular pedicle nasoseptal flap. *Laryngoscope* 116: 1882–1886, 2006
3) Horiguchi K, Murai H, Hasegawa Y, Hanazawa T, Yamakami I, Saeki N: Endoscopic endonasal skull base reconstruction using a nasal septal flap: surgical results and comparison with previous reconstructions. *Neurosurg Rev* 33: 235–241, discussion 241, 2010
4) Kassam AB, Thomas A, Carrau RL, et al.: Endoscopic reconstruction of the cranial base using a pedicled nasoseptal flap. *Neurosurgery* 63: ONS44–52; discussion ONS52–53, 2008
5) Locatelli D, Rampa F, Acchiardi I, Bignami M, De Bernardi F, Castelnuovo P: Endoscopic endonasal approaches for repair of cerebrospinal fluid leaks: nine-year experience. *Neurosurgery* 58: ONS246–ONS256; discussion ONS–256–ONS257, 2006
6) Long LZ, Brown S, Anand VK, Schwartz TH: “Gasket-seal” watertight closure in minimal-access endoscopic cranial base surgery. *Neurosurgery* 62: ONS342–ONS343; discussion ONS343, 2008
7) Kobayashi H, Asaoka K, Terasaka S, Murata JI: Primary closure of a cerebrospinal fluid fistula by nonpenetrating titanium clips in endoscopic endonasal transsphenoidal surgery: technical note. *Skull Base* 21: 47–52, 2011
8) Kassam A, Carrau RL, Snyderman CH, Gardner P, Mintz A: Evolution of reconstructive techniques following endoscopic expanded endonasal approaches. *Neurosurg Focus* 19: E8, 2005
9) Lazaridis N, Natsis K, Koebke J, Themelis C: Nasal, sellar, and sphenoid sinus measurements in relation to pituitary surgery. *Clin Anat* 23: 629–636, 2010

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