Osaka Sliding Knot Seals Dural Defect Simply in Extended Endoscopic Endonasal Approach

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“Osaka sliding knot” seals dural defect simply in extended endoscopic endonasal approach

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Abstract

An extended endoscopic endonasal approach (EEA) has become standard for parasellar and midline skull base lesions. However, postoperative leakage of cerebrospinal fluid (CSF) can result from dural defects after lesion removal. We present a simple and effective technique, the Osaka sliding knot, to prevent CSF leakage. Between November 2018 and March 2021, a total of 41 patients underwent reconstruction of skull base defects with intraoperative high-flow CSF leaks after extended EEA by using this closure technique, of whom only 1 patient experienced postoperative CSF leakage. This technically simple and efficient method seals the dural defect to prevent CSF leakage following surgeries using an extended endoscopic endonasal approach.

Introduction:

An extended endoscopic endonasal approach (EEA) has become standard for parasellar and midline skull base lesions like pituitary adenomas, craniopharyngiomas, skull base meningiomas, chordomas, chondrosarcomas, epidermoid cysts, teratomas and Rathke's cleft cysts [1]. Depending on the location, size and extent of the lesion, drilling of the tuberculum sellae, sellar floor, and parasellar structures is very common during extended skull base approaches. For maximum tumor resection, the dural opening has to be wide to access the lesion. Arachnoid breach or opening of the third ventricle during tumor resection can be very common, increasing the rate of postoperative cerebrospinal fluid (CSF) leakage. Nasoseptal flaps are the most commonly used, widely described and relied upon method to prevent CSF leakage, and many skull base reconstruction techniques have improved the surgical results [2-9].

Surgical knots are recognized as important elements in surgical performance and technique. However, forming a knot inside the nose is difficult, where the narrow working space greatly restricts instrument movement. The aim of this report was to show the technical steps and demonstrate the simplicity and effectiveness of the "Osaka sliding knot" in cases with intraoperative high-flow CSF leaks after endoscopic endonasal skull base surgery. We mainly concentrate on the steps of tying the knot outside the nose, then sliding it inside the nasal cavity to approximate the dural edges, and also describe how the knot holds the fat graft in place.

Materials and Methods

A total of consecutive 41 patients underwent extended EEA with intraoperative large CSF leak (CSF leak grade 3[1]) and skull base repair by using "Osaka sliding knot" technique between November 2018 and March 2021. In this procedure, a needle

(diameter, 9.3 mm; 3/8 circle) with 6–0 monofilament (polypropylene, Ethicon PROLENE®; Johnson & Johnson, USA) (Fig. 1A) and a deep suturing needle holder (Valve Gate^{TM} Needle Holders with ratchet, catalog number 34-7806; Geister Medizintechnik, Germany) (Fig. 1B) are used to stitch the dura. Figure 2 provides a schematic of the method for tightening and sliding the knot ,"Osaka sliding knot". The surgeon holds both threads to form a loop (Fig. 2A), then the assistant surgeon makes the first throw, second throw and final third throw (Fig. 2B), and brings back the thread into the preformed loop (Fig. 2C). Holding and pulling on the same end, the knot is tightened outside the nose (Fig. 2D). The knot is slid inside the nasal cavity by pulling on the other end (Fig. 2E). Finally, additional pulling on the threads on both sides near the knot is performed for further tightening of the knot inside the nose(Fig. 2F).

Illustrative case (Video 1)

A 39-year-old woman with a 3-month history of visual dysfunction in the left eye identified the left cavernous sinus (CS) meningioma with compression of the optic chiasm and left optic nerve. The lesion was resected via an extended endoscopic endonasal approach with upper clivectomy and posterior clinoidectomy[10]. After tumor resection, a large dural defect was evident around the sellar floor (Fig. 3A). Skull base reconstruction involving multi-layered reconstruction was therefore performed to prevent CSF leakage. With the help of a needle holder, stitches were made at the dural edges (Fig. 3B). Both ends of sutures are taken outside the nose. The surgeon holding both threads forms a loop, then the assistant surgeon makes the first throw, second throw and final third throw and brings back the thread into the preformed loop. By holding and pulling on the same end,

the knot is tightened outside the nose (Fig. 3C). The knot is slid inside the nasal cavity by pulling on the other end. This can be seen by introducing the endoscope inside the nasal cavity through the other nostril (Fig. 3D). This leads to approximation of the dural edges, and pulling on threads from both sides near the knot is added to further tighten the knot inside the nose (Fig. 3E). By adding the fat graft and taking multiple sutures to the dural edges and as well as the fat graft, with the help of sliding knots, a tight reconstruction is formed (Fig. 3F). This sliding knot keeps the fat graft in position and prevents CSF leakage (Fig. 3G). We can place multiple sutures to reinforce our reconstruction. The nasoseptal flap covers the sellar floor widely at the end (Fig. 3H). No CSF leakage or neurological worsening was identified.

Results

From November 2018 through March 2021, 41 consecutive patients (63% women; mean age 50 years, range 5-76 years) underwent extended EEA with intraoperative CSF leak grade 3 and skull base repair by using "Osaka sliding knot" technique (Table 1). 14 (34.1%) of these patients had prior surgery. The histological diagnoses included 27 craniopharyngiomas, 13 skull base meningiomas (6 CS meningiomas, 5 diaphragma-sellae meningioma, 1 posterior clinoid meningioma), 1 glioma and 1 epidermoid. Detail of surgical procedures was as follows; Extended EEA with upper clivectomy and posterior clinoidectomy was applied for 25 craniopharyngiomas, 6 CS meningiomas, 3 diaphragma-sellae meningiomas, 1 posterior clinoid meningioma and 1 hypothalamic glioma. Transplanum approach was applied for 2 craniopharyngiomas and 2 diaphragma-sellae meningiomas. The average number of knots in one case was 2.7 (range 1 - 6 knots) and, average time to make one tied suture at the dural edge was 6.3

minutes (range 3.5 - 12 minutes). Postoperative continuous spinal drainage was applied for 25 patients between November 2018 and June 2020, and no continuous spinal drainage was used postoperatively in recent cases.

Only 1 patient with craniopharyngioma showed postoperative CSF leakage and required additional repair surgery two weeks after tumor resection. No other patients showed postoperative CSF leakage, and no other complications arising from the use of this knot technique were observed in the present series. Table 1 shows clinical data and outcomes of 41 patients with skull base reconstruction by using "Osaka sliding knot" via an extended EEA.

Discussion

Surgical knots are recognized as an essential factor affecting the end results of surgical procedures and represent the most important determinant of success in various endoscopic operations. Particularly in nasal endoscopic surgery, suturing techniques are useful for preventing CSF leakage, but show a level of difficulty that is so high that these techniques are infrequently used. Laparoscopic surgery has a longer history than neuroendoscopic surgery, and various suturing methods have been described.

Laparoscopic sutures are mainly divided into intra- and extraperitoneal knot methods in which the created loop is sent from outside the body to the suture inside the body [11-13]. The intraperitoneal knot method is a technique in which a suture is wrapped around forceps, but is not suitable for nasal endoscopy with a narrow surgical field. For this reason, in endoscopic endonasal surgery, the knot method in which the created knot outside the nasal cavity is sent to the suture site is considered to be a simple and highly convenient method. Sliding knot techniques have also been reported in some articles [14-16], but have used more complicated methods of making the knot compared to our

method. The first characteristic point in our method is that there is no need to use a specially designed instrument such as a knot tightener or knot pusher. The second characteristic is making the knot with four hands. The procedure itself is simple, but with the operator and assistant making the knot cooperatively, knot creation can be simplified further. Other key points of our methods were as follows. While sliding the knot, we sometimes encountered dural edge tears. Dural defects tend to be larger when tumors extend around parasellar structures, and the dural edge is smaller and thinner in such cases. When sliding the knot, strong tension creates tears in the weak dural edge. To prevent dural tears, intentionally making a "loose" knot to decrease friction during sliding and tightening the knot after sliding it into the nostril is effective. Alternatively, making throws only two times is also effective to decrease friction.

Various techniques for closing CSF leaks have been advocated by different authors, including closure techniques using a nasoseptal flap, fascia or an artificial plate [1,2,4-6,8,9,17]. On the other hand, the surgeon must adjust the size of the fascia to that of the dural defect and manipulating the fascia in the nostril is difficult during an endoscopic endonasal approach. Nasoseptal flaps are the most commonly used, described and relied-upon method to prevent CSF leakage. many skull base reconstruction techniques have improved the surgical results [2-9]. Still, the incidence of CSF leakage in cases of CSF leak grade 3 is remains at 4.8–10% [18,19]. We have encountered only one case (2.3%) of repair failure in 41 cases with intraopertative high-flow CSF leaks (CSF grade 3). According to intraoperative findings from reoperation in that case, the nasoseptal flap had not engrafted due to poor blood flow to the flap. Preserving blood flow in the mucosal flap is clearly important, but our repair failure rate is very low, suggesting that our method may improve CSF leakage rates. Initially, lumbar drainage was used,

however due to the low incidence of cerebrospinal fluid leakage in sutured cases, we decided to discontinue lumbar drainage. Our closure method using the “Osaka sliding knot” thus seems very effective and simple.

Conclusion

We have reported the details of the Osaka sliding knot. The method is simple, as the knot is formed outside the nose and is then slid inside. In addition, the chances of knot loosening are very low with three throws. The knot helps hold the fat or fascia graft in place and prevent dislodgment. The Osaka sliding knot is a technically simple and efficient method to prevent postoperative CSF leakage following an extended EEA.

References :

1. Esposito F, Dusick, JR Fatemi N, Kelly DF: Graded repair of cranial base defects and cerebrospinal fluid leaks in transsphenoidal surgery. Oper Neurosurg (Hagerstown), 2007 Apr;60(4 Suppl 2):295-303; discussion 303-4.doi: 10.1227/01.NEU.0000255354.64077.66.

2. Cavallo LM, Solari D, Somma T, Cappabianca P: The 3F (Fat, Flap, and Flash) Technique For Skull Base Reconstruction After Endoscopic Endonasal Suprasellar Approach. World Neurosurg. 2019 Jun;126:439-446.doi: 10.1016/j.wneu.2019.03.125. Epub 2019 Mar 20.PMID: 30904811

3. Gondim JA, Almeida JP, Albuquerque LA, Schops M, Gomes E, Ferraz T, Sobreira W, Kretzmann MT: Endoscopic endonasal approach for pituitary adenoma: surgical complications in 301 patients. Pituitary. 2011 Jun;14(2):174-83. doi: 10.1007/s11102-010-0280-1.PMID: 21181278

4. Hara T, Akutsu H, Yamamoto T, Tanaka S, Takano S, Ishikawa E, Matsuda M, Matsumura A: Cranial Base Repair Using Suturing Technique Combined with a Mucosal Flap for Cerebrospinal Fluid Leakage During Endoscopic Endonasal Surgery. World Neurosurg. 2015 Dec;84(6):1887-93. doi: 10.1016/j.wneu.2015.08.025. Epub 2015 Sep 1.PMID: 26341445

5. Horiguchi K, Nishioka H, Fukuhara N, Yamaguchi-Okada M, Yamada S: A new multilayer reconstruction using nasal septal flap combined with fascia graft dural suturing for high-flow cerebrospinal fluid leak after endoscopic endonasal surgery. Neurosurg Rev. 2016 Jul;39(3):419-27. doi: 10.1007/s10143-016-0703-1. Epub 2016 Feb 17.PMID: 26886779

6. Kassam AB, Thomas A, Carrau RL, Snyderman CH, Vescan A, Prevedello D, Mintz A, Gardner P: Endoscopic reconstruction of the cranial base using a pedicled nasoseptal flap. Neurosurgery. 2008 Jul;63(1 Suppl 1):ONS44-52; discussion ONS52-3. doi: 10.1227/01.neu.0000297074.13423.f5.PMID: 18728603

7. Koutourousiou M, Fernandez-Miranda JC, Stefko ST, Wang EW, Snyderman CH, Gardner PA: Endoscopic endonasal surgery for suprasellar meningiomas: experience with 75 patients. J Neurosurg. 2014 Jun;120(6):1326-39. doi: 10.3171/2014.2.JNS13767. Epub 2014 Mar 28.PMID: 24678782

8. Liu JK, Schmidt RF, Choudhry OJ, Shukla PA, Eloy JA: Surgical nuances for nasoseptal flap reconstruction of cranial base defects with high-flow cerebrospinal fluid leaks after

endoscopic skull base surgery. Neurosurg Focus. 2012 Jun;32(6):E7. doi: 10.3171/2012.5.FOCUS1255.PMID: 22655696 Review.

9. Takeuchi K, Nagatani T, Wakabayashi T: How I do it: shoelace watertight dural closure in extended transsphenoidal surgery. Acta Neurochir (Wien). 2015 Dec;157(12):2089-92. doi: 10.1007/s00701-015-2612-4. Epub 2015 Oct 19.PMID: 26477503

10. Ohata H, Goto T, Nagm A, Kannepalli NR, Nakajo K, Morisako H, Goto H, Uda T, Kawahara S, Ohata K: Surgical implementation and efficacy of endoscopic endonasal extradural posterior clinoidectomy. J Neurosurg. 2019 May 3:1-9. doi: 10.3171/2019.2.JNS183278. Online ahead of print.PMID: 31051459

11. Murad F, Ali Q, Masiha SA, et al: Roeder's knot: solution to intra-corporeal knot tying. *Journal of Rawalpindi Medical College*. 2013;17(2):181-4

12. Ramirez OM, Tezel E, Ersoy B: The Peruvian fisherman's knot: a new, simple, and versatile self-locking sliding knot. Ann Plast Surg. 2009 Feb;62(2):114-7. doi: 10.1097/SAP.0b013e31817e2c9e.PMID: 19158516

13. Taylor FW: SURGICAL KNOTS. Ann Surg. 1938 Mar;107(3):458-68. doi: 10.1097/00000658-193803000-00011.PMID: 17857148

14. Amano K, Okada Y, Kawamata T: Usefulness of the knot-tightener device following dural suturing in endonasal transsphenoidal surgery: technical report. Neurosurg Rev. 2019 Jun;42(2):593-598. doi: 10.1007/s10143-019-01090-8. Epub 2019 Mar 1.PMID: 30825013

15. Ishii Y, Tahara S, Oyama K, Kitamura T, Teramoto A: Easy slip-knot: a new simple tying technique for deep sutures. Acta Neurochir (Wien). 2011 Jul;153(7):1543-5; discussion 1545. doi: 10.1007/s00701-011-0988-3. Epub 2011 Mar 26.PMID: 21442352

16. Sakamoto N, Akutsu H, Takano S, Yamamoto T, Matsumura A: Useful 'sliding-lock-knot' technique for suturing dural patch to prevent cerebrospinal fluid leakage after extended transsphenoidal surgery. Surg Neurol Int. 2013;4:19. doi: 10.4103/2152-7806.107546. Epub 2013 Feb 20.PMID: 23493948

17. Ishikawa T, Takeuchi K, Nagata Y, Choo J, Kawabata T, Ishizaki T, Wakabayashi T: Three types of dural suturing for closure of CSF leak after endoscopic transsphenoidal surgery. J Neurosurg. 2018 Oct 1:1-7. doi: 10.3171/2018.4.JNS18366. Online ahead of print.PMID: 30485207

18. Conger A, Zhao F, Wang X, Eisenberg A, Griffiths C, Esposito F, Carrau RL, Barkhoudarian G, Kelly DF: Evolution of the graded repair of CSF leaks and skull base defects in endonasal endoscopic tumor surgery: trends in repair failure and meningitis rates in 509 patients. J Neurosurg. 2018 May 11;130(3):861-875. doi: 10.3171/2017.11.JNS172141.PMID: 29749920

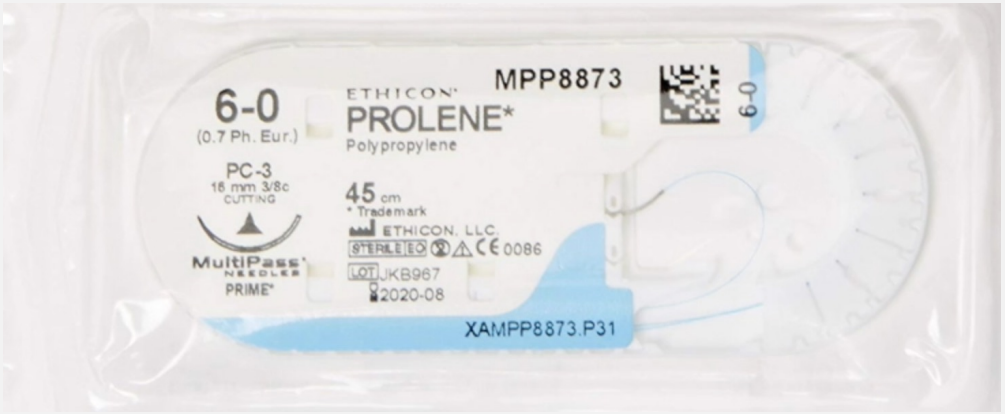
19. Ogiwara T, Nagm A, Hasegawa T, Hanaoka Y, Ichinose S, Goto T, Hongo K: Pitfalls of skull base reconstruction in endoscopic endonasal approach. Neurosurg Rev. 2019 Sep;42(3):683-689. doi: 10.1007/s10143-018-1006-5. Epub 2018 Jul 7.PMID: 29982857

Figure legends

Fig. 1

A: Needle (diameter, 9.3 mm; 3/8 circle) with 6–0 monofilament

B: Deep suturing needle holder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(0.7 Ph. Eur.)
PC-3
16 mm 3/8c
CUTTING
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6-0

A

B

Fig.1

Fig. 2

Schematic of how to tighten and slide the Osaka sliding knot

A: Form a loop

B: Make the first throw, second throw and final third throw

C: Bring back the thread into the preformed loop

D: Hold and pull the same end to tighten the knot outside the nose.

E: Pull on the other end to slide the knot inside the nasal cavity.

F: Additional pulling on the threads on both sides near the knot inside the nose.

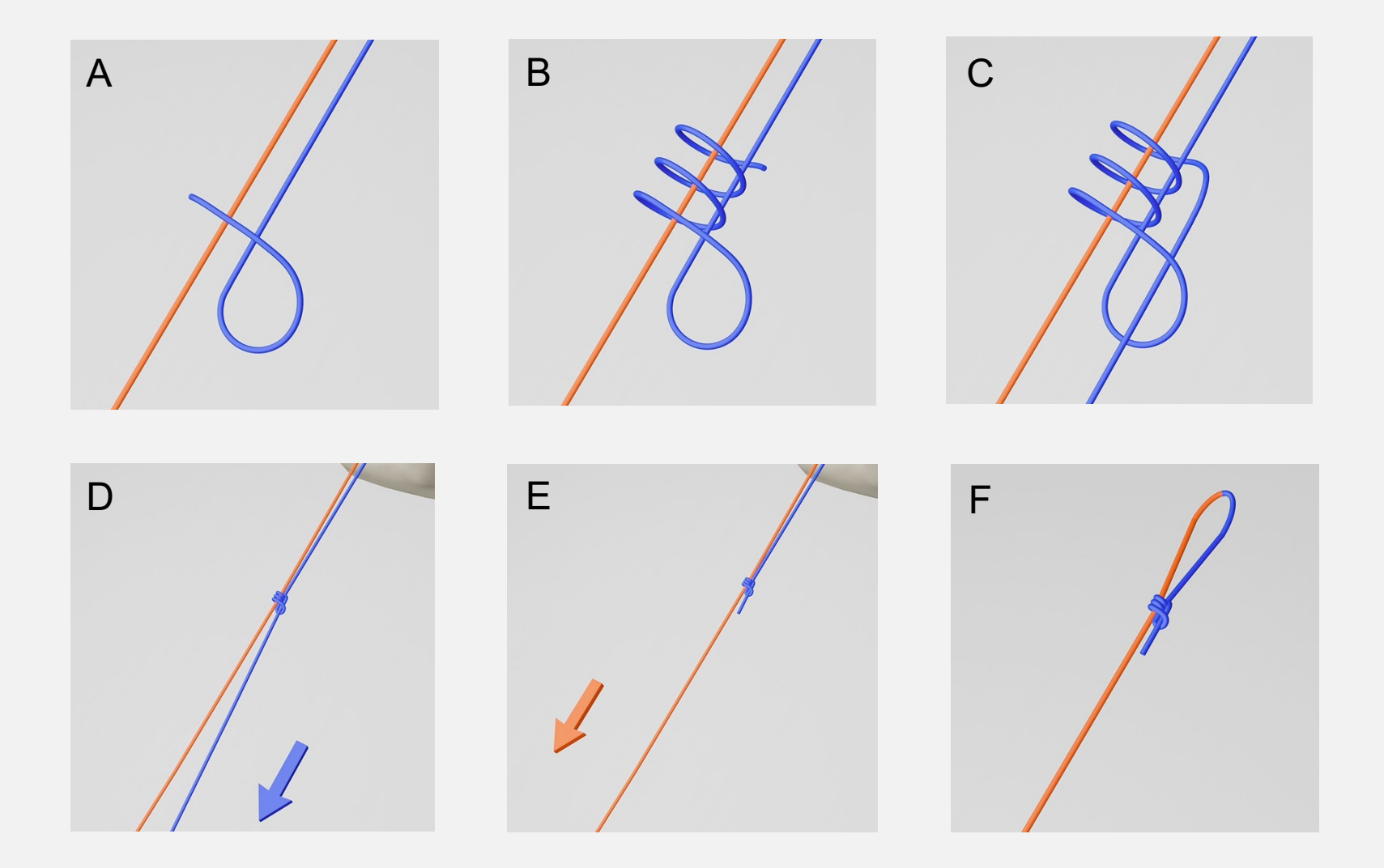


Fig.2

Fig. 3

A: Large dural defect after tumor resection

B: Stiches placed at dural edges

C: Knot tightened outside the nose

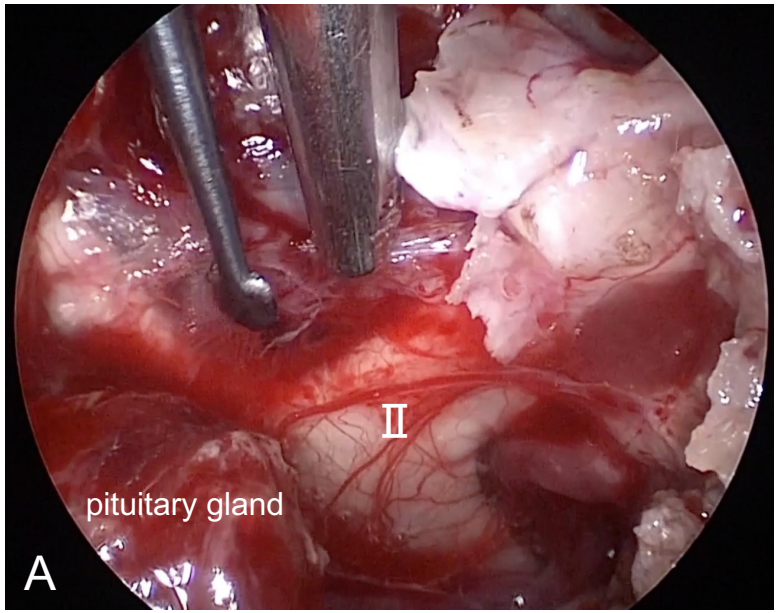
D: Sliding knot inside the nasal cavity

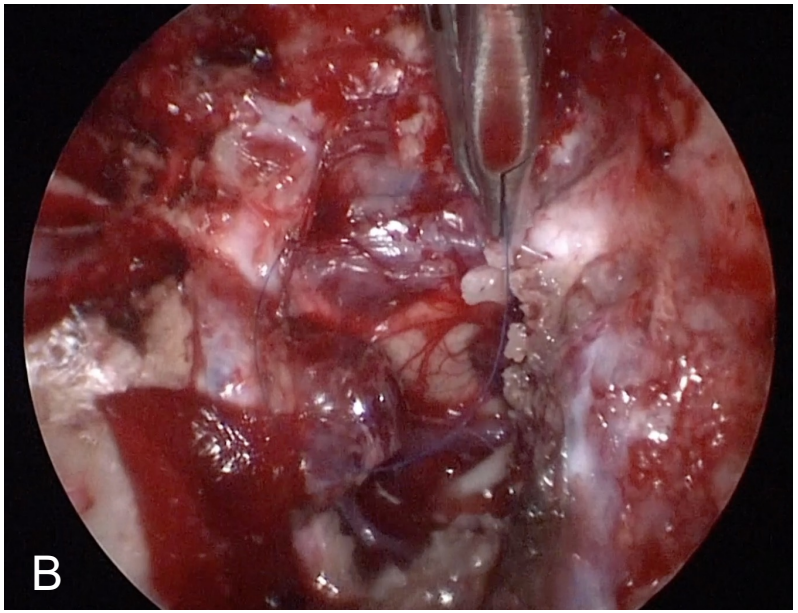
E: Pulling on the dural stump with further knot tightening

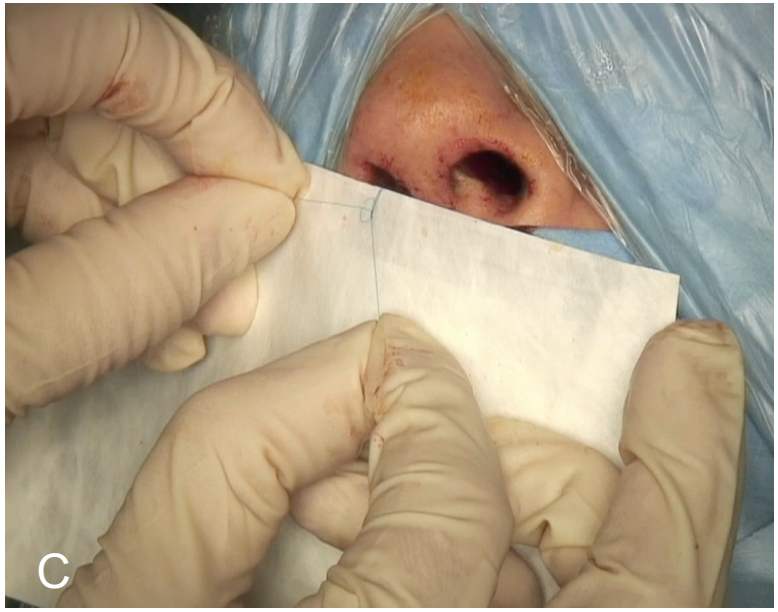
F: Multiple sutures between the dural edges and fat graft

G: Knots keep the fat graft in position

H: Sealing the sellar floor using a nasoseptal flap







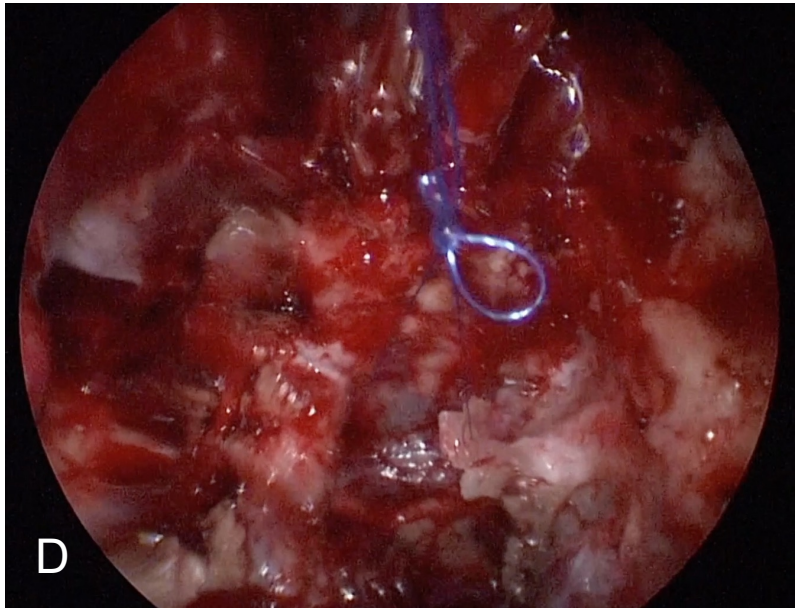


Fig.3

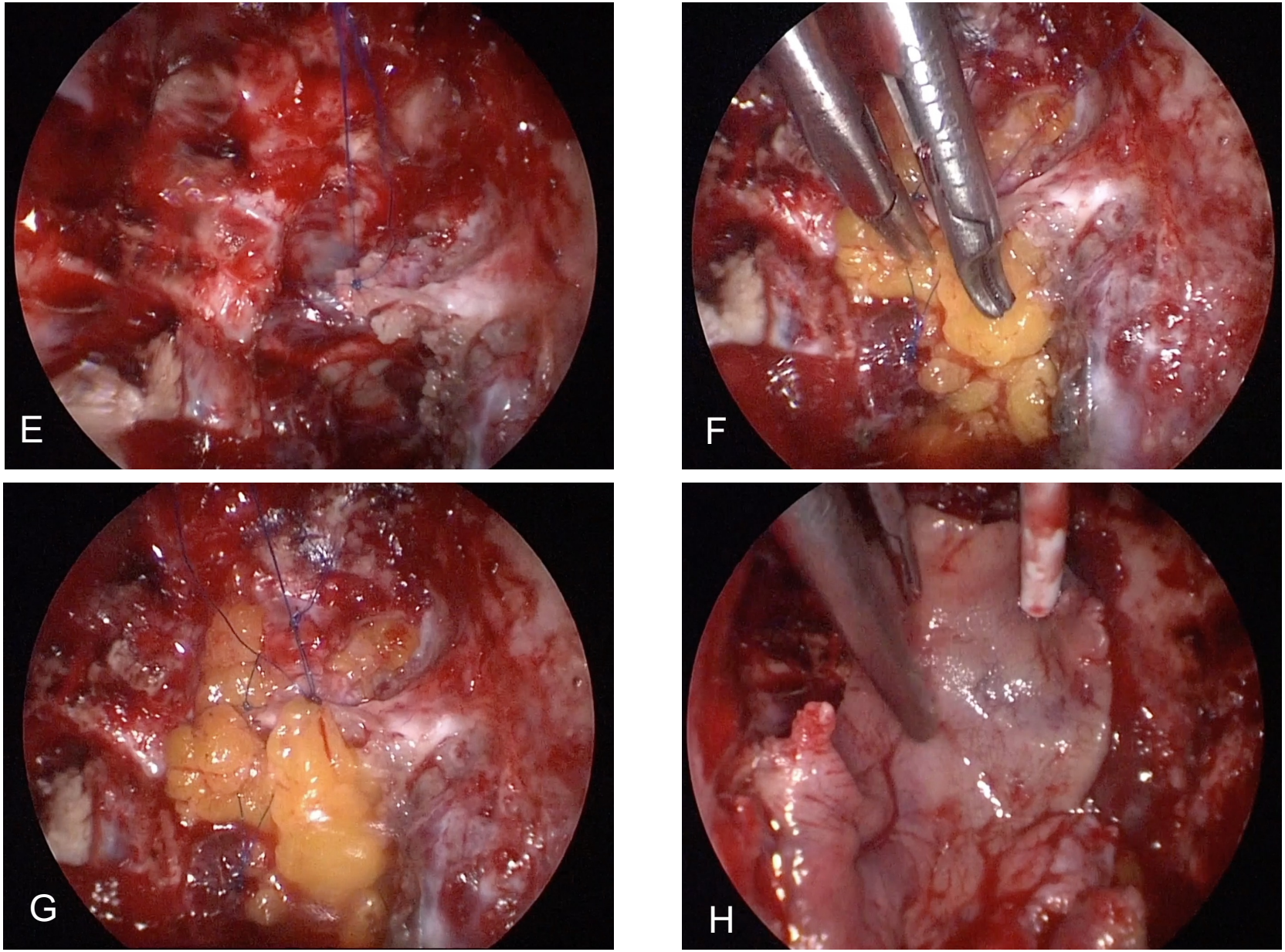


Fig.3

Video transcript

0s-6s: Title page
6s-32s: The aim of this presentation is to show the technical steps, simplicity and effectiveness of the Osaka knot to prevent CSF leakage. This presentation mainly concentrates on the procedure of how to tie the knot outside the nose and then slide it inside the nasal cavity to approximate the dural edges, and also how this knot holds the fat graft in place.
32s-41s: In all cases, we use prolene six zero, and an endoscopic needle holder to make the stitches.
41s-1m5s: This is animated video shows the simplicity of tying the knot outside the nose. After three throws, the suture is brought to the loop and pulled to form a knot. By pulling the other end, the knot is slid inside the nasal cavity.
1m5s-1m18s: Depending upon the location, size and extent of the tumor, drilling of tuberculum sella, sellar floor, or parasellar structures is very common during extended skull base approaches.
1m18s-1m33s: For maximum tumor resection, the dural opening must be wide to properly access the tumor. Arachnoid breach or opening of the ventricles can be quite common during tumor resection, and these events increase the postoperative CSF leakage rate.
1m33s-1m50s: With the help of a needle holder, stiches can be made at the dural edges. Both ends of sutures are taken outside the nose.
1m50s-2m-38s: Now the surgeon holding both ends of the thread forms a loop, the assistant surgeon makes the first, second and final third throw, then brings the thread back into the preformed loop.
2m38s-3m02s: By holding and pulling the same end, the knot is then tied outside the nose. This knot is slid inside the nasal cavity by pulling on the other end.
3m02s-3m20s: This can be seen by introducing the endoscope inside the nasal cavity through the other nostril. Approximation of the dural edges is achieved, as seen here.
3m20s-3m45s: By adding a fat graft and taking multiple sutures to the dural edges and the fat graft, a tight reconstruction is made with the help of these sliding knots. These sliding knots keep the fat graft in position and prevent CSF leakage. We can use multiple sutures to reinforce the reconstruction.
3m45s-3m52s: Nasoseptal flap is added for sealing at the end.
3m52s-4m18s: This video shows how we practice and master knot tying with the assistant surgeon before surgery.

4m18s-4m42s: Making a knot inside the nose is difficult in a narrow space where instrument movement is markedly restricted. Our method is simple, as the knot is made outside the nose and then slid inside. Also, the chances of knot loosening are very low with three throws. The knot helps hold the fat graft in place and prevents dislodgment.
4m42s-5m0s: To conclude, we would like to say that the Osaka sliding knot is a technically simple and efficient method to seal the dural defect and prevent CSF leaks during extended endoscopic skull base approaches.