Cerebrospinal fluid rhinorrhea: classification and guidelines for endoscopic repair

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Cerebrospinal fluid rhinorrhea: classification and guidelines for endoscopic repair

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Background: Cerebrospinal fluid (CSF) rhinorrhea may be traumatic, developmental, pathological, or spontaneous. Different routes were suggested to approach the defect and many techniques were introduced for repair.

Objective: To present a new classification of CSF rhinorrhea based on the detailed site of the skull base defect and to demonstrate how to utilize it in determining the best approach for repair.

Methods: Ninety four cases of CSF leak having 103 skull base defects were classified according to their detailed sites. The approach followed to repair the defect was designed according to the site of the leak. These approaches included the endoscopic transcribriform, transethmoid, axillary flap technique, transnasal transsphenoid, transpterygopalatine, direct transnasal and external osteoplastic flap.

Results: Transnasal endoscopic approach was useful to approach all sites except the lateral frontal sinus defects, where external osteoplastic flap was mandatory. Transcribriform approach was effective in anterior and posterior cribiform plate defects. Transethmoid approach was useful in anterior and posterior ethmoids leaks. Axillary flap technique was sufficient in medial frontal sinus and frontal recess lesions. Transnasal transsphenoid approach was efficient in central sphenoid sinus defects and transpterygopalatine fossa in lateral recess leaks. Direct transnasal approach was resorted to in case of absent middle turbinate. These different approaches offered enough exposure of the defect for repair. Primary closure was achieved in 93.9% of defects and secondary closure in 100%.

Conclusion: Classification of CSF rhinorrhea according to the detailed site of skull base defect helps select the most direct and least destructive approach with effective repair.

Keywords: Cerebrospinal fluid rhinorrhea, CSF leak, skull base defect, repair, classification, endoscopic surgery.

INTRODUCTION

Cerebrospinal fluid (CSF) rhinorrhea may be traumatic, pathological, developmental or spontaneous. The leak may be located at the ethmoid roof, cribiform plate, posterior wall of frontal sinus, or the sphenoid sinus.

Surgical repair may be achieved transcranially through a bifrontal craniotomy, extracranially through an external ethmoidectomy or osteoplastic flap, or transnasally with microscopic or endoscopic visualization.

In recent years the popularity of endoscopic closure of CSF leak has continually increased and in most cases, endoscopic nasal surgery has almost completely replaced more traumatic transcranial and extracranial procedures.

The endoscopic technique offers a direct access, exact identification of the site of the dural tear and precise placement of the graft. It permits preservation of the functional anatomy of the nose including smell.
offers shortened operating time in conjunction with success rates of 90% after primary attempts and 97% after secondary repair.\(^{(3,10,11)}\)

The most commonly used classifications of cerebrospinal fluid rhinorrhea are based on the etiology.\(^{(1)}\) There is no classification based on the detailed site of skull base defects. Moreover there are no clear guidelines for the optimum approach utilized in each defective site.

The aim of work of this study is to present a new classification of skull base defects based on the detailed site of the leak and to demonstrate how to utilize it as a roadmap to select the most appropriate approach for leak repair.

**PATIENTS AND METHODS**

This study included cases of CSF leak presenting to the ENT outpatient clinic of Cairo University Hospital between July 1997 and August 2011, operated upon by the first author. Cases with persistent leak for more than 3 months refractory to conservative therapy were included. Cases of iatrogenic leak or leak associated with meningoceles or meningoencephalocele were also included.

Cases of comminuted fractures of skull base, cases with prior attempts for repair, and patients with CSF rhinorrhea of temporal bone were excluded.

Endoscopy was performed in all cases before surgery to assess the nasal cavity, follow the leak to the affected site, and to detect any associated pathology. Immunofixation of beta-2-transferrin was resorted to in suspicious cases. To define the site of the leak preoperatively, high resolution CT and/or CT cisternography were performed. In case of suspected meningocele or meningoencephalocele, MRI study was performed.

Ninety four cases of CSF leak were operated upon under general anesthesia. In case of defects of the cribiform plate, the leak was approached via the transcribriform approach, medial to the middle turbinate in case of anterior cribiform or medial to the superior turbinate in case of posterior cribiform. In case of defects of the fovea ethmoidalis or lateral lamella, the transethmoid approach was utilized where the uncinate process was excised and agger nasi cells were removed with preservation of the bulla ethmoidalis. In case of defects of the central sphenoid sinus either from the planum sphenoidale, sellar floor or clivus, the transnasal transsphenoid approach was followed. The sphenoid sinus ostium was identified between the superior turbinate and nasal septum and widened. In case of defects of the lateral recess of the sphenoid sinus, the transpterygopalatine fossa approach was followed. Anterior and posterior ethmoidectomy, wide middle meatal antrostomy and sphenoid marsupialization were performed. The posterior wall of the maxillary sinus and anterior lip of the sphenopalatine foramen were drilled. The periosteum of the pterygomaxillary fossa was then displaced laterally to expose the vidian nerve and canal then the maxillary nerve lateral and superior.

In case of defects of the lateral part of posterior wall of the frontal sinus, lateral to the sagittal plane through the lamina papyracea, external osteoplastic approach was performed. (Fig. 1) shows the different detailed sites of CSF leaks and approaches used for repair. In case of absence of middle turbinate (4 cases, 4.25%), due to disease or prior surgery, direct transnasal approach was adopted.

The site of the defect was confirmed intra-operatively, by identification of the leak and washout sign. Blue-light filter and pre-operative intrathecal fluorescein were utilized in one case. In case of failure to define the site of the leak, intraoperatively, Valsalva-like maneuver, and intra-operative intrathecal fluorescein [2 cases] were performed.

After identification of the defect, the surrounding bone was exposed by mucosal dissection. In case of cribiform defects, due to the tiny space available, the mucosa around the defect was cauterized to expose the bone. In small defects ≤ 5 mm, nasal septal mucoperichondrium graft was harvested from the contra lateral side. In case of large defects > 5mm, fascia lata was utilized. Fat was added in lateral frontal sinus, sphenoid sinus and large fovea ethmoidalis defects. Graft was applied in an on-lay fashion and Gelfoam was put on top. Sofartule was then introduced followed by anterior nasal pack. The anterior nasal pack was left for 2 days and the sofratule for 5 days. All patients received peri-operative antibiotics and no lumbar drain was used.

In case of meningocele or meningoencephalocele, it was cauterized using bipolar cautery to ablate prolapsed tissue till the site of the defect was identified and repaired.

Image guided system [IGS] was utilized in leaks of the lateral recess of sphenoid sinus.
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Fig. 1 shows the different detailed sites of CSF rhinorrhea and the approaches utilized for repair. Sites of skull base defects: 1. posterior wall of the frontal sinus, lateral and medial to the sagittal plane through lamina papyracea respectively, 3. frontal recess, 4. fovea ethmoidalis, 5. lateral lamella, 6. anterior cribiform plate, 7. posterior cribiform plate, 8. posterior ethmoid, 9. planum sphenoidale, 10. sellar floor, 11. clivus, 12. lateral recess. Approaches used in the study: I. external osteoplastic flap, II. axillary flap, III. Transethmoid [anterior and posterior], IV. transcribriform, V. transsphenoidal, VI. transpterygopalatine fossa. In case of absence of middle turbinate due to disease or prior surgery (2 cases, 3.8%), the direct transnasal approach was adopted.

RESULTS

Ninety four cases of CSF leak were included. There were 30 males (32%) and 64 females (68%). Age ranged between 6 and 72 years [mean 41 years]. Eighty nine cases presented by unilateral rhinorrhea (94.7%) and 5 by bilateral rhinorrhea (5.3%). Unilateral rhinorrhea was from the right side in 52 cases (55%) and left in 37 cases (39.4%). Forty four cases (46.8%) had a history of meningitis. The period of CSF leak prior to surgery ranged between 3 months and 7 years [average 15 months].

Table 1 shows the etiology of CSF leak. Table 2 shows the sites involved by the skull base defect in general and in details. It was noticed that the most common site involved was the anterior ethmoid (40%) followed by cribiform plate (30%). Concerning the detailed site, the most common site was the lateral lamella of ethmoid bone (26%) followed by anterior cribiform plate (24%) and then fovea ethmoidalis (14%).

Table 1 shows the etiology of CSF leak in the 94 cases of skull base defects.

<table>
<thead>
<tr>
<th>Aetiology</th>
<th>No of patients</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Spontaneous</td>
<td>47</td>
<td>50</td>
</tr>
<tr>
<td>Developmental</td>
<td>20</td>
<td>21</td>
</tr>
<tr>
<td>Accidental traumatic</td>
<td>14</td>
<td>14.9</td>
</tr>
<tr>
<td>Iatrogenic</td>
<td>10</td>
<td>10.6</td>
</tr>
<tr>
<td>Pathological</td>
<td>3</td>
<td>1.2</td>
</tr>
<tr>
<td>Total</td>
<td>94</td>
<td>100</td>
</tr>
</tbody>
</table>

Table 2. Shows the general and detailed sites of skull base defect in the 94 cases of skull base defects.

<table>
<thead>
<tr>
<th>General site of skull base defect</th>
<th>No</th>
<th>%</th>
<th>Detailed Site of defect</th>
<th>No</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frontal sinus</td>
<td>11</td>
<td>9.6</td>
<td>Lateral</td>
<td>4</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Medial</td>
<td>2</td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Frontal recess</td>
<td>5</td>
<td>4.4</td>
</tr>
<tr>
<td>Anterior ethmoid</td>
<td>46</td>
<td>40</td>
<td>Fovea ethmoidalis</td>
<td>16</td>
<td>14</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lateral lamella</td>
<td>30</td>
<td>26</td>
</tr>
<tr>
<td>Cribriform plate</td>
<td>34</td>
<td>30</td>
<td>Anterior</td>
<td>27</td>
<td>24</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Posterior</td>
<td>7</td>
<td>6.1</td>
</tr>
<tr>
<td>Posterior ethmoid</td>
<td>9</td>
<td>7.9</td>
<td>Posterior ethmoid</td>
<td>9</td>
<td>7.9</td>
</tr>
<tr>
<td>Sphenoid sinus</td>
<td>14</td>
<td>12</td>
<td>Planum sphenoidale</td>
<td>4</td>
<td>3.5</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Sellar floor</td>
<td>3</td>
<td>2.6</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Clivus</td>
<td>2</td>
<td>1.8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lateral recess of sphenoid sinus</td>
<td>5</td>
<td>4.4</td>
</tr>
<tr>
<td>Total</td>
<td>114</td>
<td>100</td>
<td>Total</td>
<td>114</td>
<td>100</td>
</tr>
</tbody>
</table>
Bilateral defects were encountered in 5 cases (5.3%). It was noticed that the lateral lamella was also the most common site affected. Bilateral cases had separate defects in four cases and in the fifth; a large meningoencephalocele was herniating through one wide defect affecting the skull base bilaterally (Fig. 2).

Table 3 shows the number of defects, sites, operations and procedures performed. Table 4 shows the approach followed in each defective site. The size of the defect was precisely defined intra-operatively. It ranged between 2 x 2 mm and 20 x 25 mm [average 4 x 6 mm]. Fifty cases (53.2%) were associated with meningocele.

Four cases with follow-up less than 3 months were excluded. Follow up ranged between 3 months and 14 years [average 52 months]. Six out of the 90 cases (6.6 %) showed persistence (1 case) or recurrence (5 cases) of leak within 3 months. Primary successful closure was achieved in 93 out of the 99 defects (93.9%). The sites of failures in the recurrent cases were medial frontal sinus, lateral frontal sinus, Fovea ethmoidalis and planum sphenoidale. The case of medial frontal sinus defect was re-operated upon successfully via the axillary flap with a follow-up of 68 months (Fig. 3). The other four cases refused any further interference. The case of persistent leak was the case of failure to identify the associated ipsilateral defect at the anterior cribriform plate, which was successfully repaired one month after primary surgery. Success was achieved in 100% of cases after secondary repair.

### Table 3. Shows the number of defects, sites, operations and procedures performed.

<table>
<thead>
<tr>
<th>Patients</th>
<th>Defects</th>
<th>Sites</th>
<th>Operations</th>
<th>Procedures</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unilateral defect:</td>
<td>89</td>
<td>84</td>
<td>79</td>
<td>79</td>
</tr>
<tr>
<td>Single defect:</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>o One site</td>
<td>79</td>
<td>79</td>
<td>79</td>
<td>79</td>
</tr>
<tr>
<td>o Two sites</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>2</td>
</tr>
<tr>
<td>o Three sites</td>
<td>3</td>
<td>3</td>
<td>9</td>
<td>3</td>
</tr>
<tr>
<td>Double defects</td>
<td>5</td>
<td>10</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>Bilateral defects:</td>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Separate defects</td>
<td>4</td>
<td>8</td>
<td>8</td>
<td>4</td>
</tr>
<tr>
<td>Continuous defect</td>
<td>1</td>
<td>1</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>94</td>
<td>103</td>
<td>114</td>
<td>96</td>
</tr>
</tbody>
</table>

### Table 4. Shows the detailed approach [102 procedures] followed in each defective site. Trans-PPF= transpterygopalatine fossa.

<table>
<thead>
<tr>
<th>Site of Skull Base Defect</th>
<th>Approach followed</th>
<th>N o</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lateral frontal sinus</td>
<td>External osteoplastic flap</td>
<td>4</td>
<td>3.9</td>
</tr>
<tr>
<td>Medial frontal sinus</td>
<td>Axillary flap</td>
<td>7</td>
<td>6.9</td>
</tr>
<tr>
<td>Frontal recess</td>
<td>Transcribriform</td>
<td>27</td>
<td>26.5</td>
</tr>
<tr>
<td>Anterior cribiform plate</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Posterior cribiform plate</td>
<td>Transitethmoid</td>
<td>46</td>
<td>45.1</td>
</tr>
<tr>
<td>Fovea ethmoidalis of anterior ethmoid</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lateral lamella</td>
<td>Transnasal transsphenoid</td>
<td>9</td>
<td>8.8</td>
</tr>
<tr>
<td>Fovea ethmoidalis of posterior ethmoid</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Planum sphenoidale</td>
<td>Transnasal transsphenoid</td>
<td>9</td>
<td>8.8</td>
</tr>
<tr>
<td>Sellar floor</td>
<td>Direct transnasal</td>
<td>5</td>
<td>4.9</td>
</tr>
<tr>
<td>Clivus</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lateral recess of sphenoid sinus</td>
<td>Trans-PPF</td>
<td>4</td>
<td>3.9</td>
</tr>
<tr>
<td>Multiple sites &amp; missing middle turbinate</td>
<td>Direct transnasal</td>
<td>5</td>
<td>4.9</td>
</tr>
<tr>
<td>Total</td>
<td>102</td>
<td>100</td>
<td></td>
</tr>
</tbody>
</table>
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Fig 2. Shows the CT of a case of large meningocele involving the anterior cribriform plate on both sides and the lateral lamella and fovea ethmoidalis on the left side. It was approached via a left direct transnasal approach.

DISCUSSION

Classifications are needed to plan surgery and compare results. CSF rhinorrhea cases are classified according to their etiology, size or site. In 1968, Ommaya et al., classified CSF rhinorrhea into traumatic and non-traumatic etiologies. The traumatic category was subdivided into accidental and iatrogenic. In the nontraumatic category a distinction was made between high pressure leaks, as may be due to tumors or hydrocephalus, and normal pressure leaks, with etiologies including osteomyelitic erosion and congenital anomalies. According to the size of the dural defect, they were divided into small (<0.4cm), intermediate (0.4–2.0cm), and large (>2.0cm). Depending on the site of the leak, skull base defects were divided into, frontal, ethmoidal, sphenoidal and olfactory cleft defects.

The authors present a new classification of CSF rhinorrhea based on the detailed site of skull base defects (Fig. 4). CSF leak may be anterior or posterior to the basal lamella of middle turbinate.

Anterior leak is medial or lateral to the vertical part of middle turbinate. Medial leak is from the anterior cribriform plate. Lateral leak is anterior or posterior to the anterior wall of bulla ethmoidalis. Posterior leak is from the lateral lamella or fovea ethmoidalis. Anterior leak is medial or lateral to the sagittal plane through the lamina papyracea. Anterior medial leak is from the frontal recess or medial part of posterior wall of the frontal sinus. Anterior lateral leak is from the lateral part of the posterior wall of the frontal sinus.

Posterior leak is medial or lateral to the superior turbinate. Lateral leak is from the roof of posterior ethmoid. Medial leak is anterior or posterior to the face of sphenoid i.e. from the posterior cribriform plate or the sphenoid sinus proper respectively. Sphenoid sinus leak is central or lateral. Central sphenoid sinus leak may be from the planum sphenoidale, sellar floor or clivus. Lateral sphenoid sinus leak is from the lateral recess of sphenoid sinus.

In most prior studies, each sinus was considered as one unit with no details of leaking sites. Some authors divided leaking sites into five regions; frontal, anterior ethmoids, posterior ethmoids, cribriform plate and sphenoid with the anterior ethmoid and cribriform most common. Others considered four regions after the exclusion of frontal lesions with cribriform most common. Others globally categorized defects into four regions; frontal, ethmoids, cribriform plate and sphenoid with anterior ethmoid and sphenoid most common. Few considered only three regions after frontal sinus exclusion with ethmoids, sphenoid and cribriform most
common in different studies. In the current study leaking sites were divided regionally into five main sites and locally into 12 detailed locations. The five regional sites were frontal, anterior ethmoids, posterior ethmoids, cribriform plate and sphenoid regions. The 12 detailed sites included: lateral and medial parts of posterior wall of frontal sinus, frontal recess, fovea ethmoidalis, lateral lamella, anterior cribriform plate, posterior cribriform plate, posterior ethmoid, planum sphenoidale, sellar floor, clivus, and lateral recess of sphenoid sinus. The most common regional site of skull base defect was anterior ethmoids (46.8%) followed by cribriform plate (29%). The most common detailed local site was the lateral lamella (32.3%) followed by the anterior cribriform plate (25.8%) and fovea ethmoidalis (14.5%).

The choice of the approach depends on the site, size, and/or etiology of the dural defect. In the current study, the approach followed for repair was tailored according to the preoperative defined detailed site of leak.

It was suggested that leaks in the cribriform plate and ethmoid roof are treated with the standard transnasal endoscopic approach. Complete endoscopic ethmoidectomy and maxillary antrostomy are performed for adequate exposure of the skull base. Frontal sinusotomy, sphenoidotomy and middle/superior turbinectomies are performed if needed for additional exposure and to avoid postoperative mucoceles.

Others stated that for defects in the medial lamella of the cribriform plate, it is preferred to go directly between the middle turbinate and the septum, localize the defect, and seal it without sacrificing the turbinate. For defects in the lateral lamella of the cribriform, anterior ethmoidectomy is done to explore the defect and seal it, also without sacrificing the middle turbinate. In the current study, the anterior and posterior cribriform plate defects were approached and repaired directly via transcribriform approach without any ethmoid workup or insult to middle or superior turbinate. Anterior ethmoid defects were handled via transnasal approach after removal of the bulla, with utmost respect to the integrity of the middle turbinate. Posterior ethmoid defects were repaired via transethmoid approach after removal of bulla ethmoidalis and penetration of the basal lamella without any insult to the superior turbinate. There was no need for sphenoidotomy, maxillary antrostomy or frontal sinusotomy in any of these sites.

In central sphenoid sinus CSF leaks the transethmoid or direct parasagittal approaches were advised. While defects located in the lateral recess of the sphenoid sinus were approached via endoscopic transpterygoid approach. In the current study the direct transnasal transpterygoid approach was performed in sphenoid sinus central leaks and the transpterygopatinate fossa approach in lateral recess defects.

It was stated that the endoscopic repair of frontal sinus CSF leaks is rarely possible because of reduced access and visibility. Only small defects of the area that can be seen bulging anteriorly when the frontal recess has been opened can be dealt with endoscopically. Frontal sinus CSF leaks were divided into 3 anatomic sites: immediately adjacent to frontal recess, direct frontal recess and frontal sinus proper. Schlosser and Bolger (2006) advised a combined above-and-below approach in direct frontal recess defects using endoscopic and open techniques.

In the five cases of pure frontal recess defect the axillary flap technique was performed and the agger cells were removed to successfully identify the defect and repair it. The Bulla ethmoidalis was left intact for graft support. Frontal sinus defects located superior or lateral require osteoplastic flap with or without obliteration. The same approach with obliteration was followed in the current study in 4 cases of laterally located frontal sinus CSF leaks. Endoscopic approach with adjuvant frontal trephination and/or an endoscopic modified Lothrop procedure were advised for unique cases of leaks located in the frontal sinus proper possibly with extension into the frontal recess. In the current study, in the case of the single defect of the medial part of posterior table of the frontal sinus adjacent to the frontal ostium, the axillary flap technique and agger nasi cells removal were sufficient for exposure and repair.

(Fig. 5) shows how to utilize the new classification in selecting the most appropriate and least destructive approach to handle each detailed defective site. In case of absence of middle turbinate due to disease or prior surgery (4 cases, 4.25%), the direct transnasal approach was adopted.

Although this classification was conducted on only primary cases and few iatrogenic CSF leaks, it could be applied also in recurrent cases of CSF rhinorrhea. In recurrent cases, and in developmental and iatrogenic leaks, which are usually associated with missing anatomical structures e.g. middle and/or superior turbinate; the approach may need some modification.

Although definite routes are suggested in the current study for each detailed defective site, combination of approaches and/or other trajectories may be adopted by different surgeons according to their experience.

With the application of the suggested new classification in selecting the trajectory followed for defect repair, primary success rate was 93.9%. And secondary success rate was 100%.
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Skull base defects [CSF Leak]

Anterior to BL

Posterior to BL

Lateral to MT

Medial to MT

Lateral to ST

Medial to ST

FS

AE

Lat

Med

FR

FE

LL

ACP

PE

PCP

PS

SF

C

LR

Fig 4. Shows the new classification of CSF rhinorrhea according to detailed site of skull base defect. BL = basal lamella, MT = middle turbinate, ST = superior turbinate, FS = frontal sinus, AE = anterior ethmoid, SS = sphenoid sinus, Lat = lateral frontal sinus, Med = medial frontal sinus, FR = frontal recess, FE = fovea ethmoidalis, LL = lateral lamella, ACP = anterior cribriform plate, PE = posterior ethmoid, PCP = posterior cribriform plate, PS = planum sphenoidale, SF = sellar floor, C = clivus, LR = lateral recess.

Skull base defects [CSF Leak]

FS

AE

PE

CP

SS

Lat

Med

FR

FE

LL

PE

ACP

PCP

PS

SF

C

LR

External

Transnasal - Endoscopic

OPF

Axillary flap

Tranethmoid

Transcribriform

Transphenoid

Trans-PPF

Fig 5. Shows how to apply the new classification in selection of the most appropriate and least destructive approach to the site of the leak. FS = frontal sinus, AE = anterior ethmoid, PE = posterior ethmoid, CP = cribriform plate, SS = sphenoid sinus, Lat = lateral frontal sinus, Med = medial frontal sinus, FR = frontal recess, FE = fovea ethmoidalis, LL = lateral lamella, PE = posterior ethmoid, ACP = anterior cribriform plate, PCP = posterior cribriform plate, PS = planum sphenoidale, SF = sellar floor, C = clivus, LR = lateral recess, OPF = osteoplastic flap, PPF = pterygopalatine fossa. In case of absence of middle turbinate due to disease or prior surgery, the direct transnasal approach was adopted.
CONCLUSIONS

Classification of the skull base defects according to the detailed site of the leak can be utilized as a roadmap for the most direct and least traumatic approach for repair. It preserves integrity of the sinonasal structures and function. It offers precise defect identification, graft application and support with good results.

Nevertheless, preoperative definition of leaking site is crucial and its application needs enough sinonasal endoscopic experience.

REFERENCES