Efficiency and therapeutic effect of modified pigtail probe in anastomosing lacerated lacrimal canaliculus

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Objective: To investigate the necessity of modification to the traditional pigtail probe and evaluate its efficiency and therapeutic effect in searching the nasal cut ends and anastomosing the lacerated lacrimal canaliculus.

Methods: Eighty-seven patients (including 87 eyes) suffering from canalicular laceration were randomized into two groups: 41 patients treated with traditional pigtail probes (Group A) and 46 with modified pigtail probes (Group B). During the reconstruction of the lacerated canaliculi, the traditional pigtail probe and the modified pigtail probe were used respectively to seek for the nasal cut ends of lacerated lacrimal canaliculi. Peripherally inserted central catheter (PICC™) silicone tube with diameter of 0.95 mm was intubated as a stent for 4-6 months. The surgical outcomes were retrospectively analyzed after stent removal.

Results: In Group B, the primary success rate of searching the nasal cut ends of lacerated lacrimal canaliculi was 93.48% (43/46) and the final success rate was 97.83% (45/46). No false passage formed in Group B. Statistical significance was found between Group A and Group B as the primary success rates of searching the nasal cut ends ($\chi^2=4.702, P<0.01$) and the false passage forming rates were concerned ($\chi^2=0.007, P>0.05$). The mean time of searching the nasal cut ends of lacerated lacrimal canaliculi in Group B was (5.02±2.73) minutes and the mean time of operation was (33.90±4.84) minutes, and both were significantly shorter than those of Group A ($t_t=9.779, t_s=10.700, P<0.01$). The cure rate of Group B was 95.65%, though higher than that of Group A, no statistical significance was found ($Z=-1.007, P>0.05$). Totally, 2 patients (2.30%) were found to be absent of common canaliculus and underwent bicanalicular nasal intubation in the two groups.

Conclusions: Pigtail probes are efficient and convenient apparatus for searching the nasal cut ends of the lacerated lacrimal canaliculi in the reconstruction of canalicular laceration. Necessary or proper modifications to the pigtail probes can minimize the risk of iatrogenic damages or complications and enhance the efficiency and therapeutic effect of canalicular repair.

Key words: Lacerations; Intubation; Lacrimal apparatus; Anastomosis, surgical
of Medical College of Qingdao University from September 2004 to September 2007 were included in this study. All these patients were randomized into two groups and underwent reconstructions of canalicular laceration by the same surgeon team. Group A, including 41 patients (37 males and 4 females, aged 18-62 years, mean: 40.7 years), was treated by bicanalicular-annular stent intubation using traditional pigtail probes 0.5-78 hours after trauma. Group B, including 46 patients (39 males and 7 females, aged 16-59 years, mean: 38.2 years), was treated by bicanalicular-annular stent intubation using the modified pigtail probes 1-84 hours after trauma. Totally, the right eye was injured in 54 patients (62.07%) and the left eye was injured in 33 patients (37.93%). Sixty-seven patients (77.01%) suffered from a single laceration of the inferior canaliculus and 20 (22.99%) from a single laceration of the superior canaliculus.

Materials and instruments

Necessary surgical materials and apparatuses included conventional lacrimal surgery instruments, a traditional pigtail probe (with a rounded end and a bye hole), a self-devised probe with a smooth tip and hollow cavity (with the outer diameter of 0.50 mm, Fig.1), a 20-gauge peripherally inserted central catheter (PICC™) silicone tube (with the outer diameter of 0.95 mm and the inner diameter of 0.51 mm. Becton Dickinson Infusion Therapy System Incorporation, Sandy, Utah, USA) and an operating microscope (S88 OPMI VISU 200, Carl Zeiss Inc, Germany).

Surgical techniques

Local anesthesia After sterilizing the operative field, regional block of the infratrochlear nerve was performed with an equal mixture of 2.0% lidocaine and 0.75% bupivacaine with 0.1% epinephrine (1:100 000). If the nasal cavity was involved in the surgical procedure, topical intranasal anesthesia and infraorbital nerve block were appended.

Retrograde intubation using the traditional pigtail probe The pigtail probe first passed through the dilated punctum of the uninvolved canaliculus. With gentle pressure, the probe advanced slowly through the common canaliculus and the proximal end of the lacerated canaliculus. Hasty operation should be avoided in case of forming false passages. If the first probing failed, cautious attempt should be repeated. Next, a 5-0 dacron suture with a segment of PICC silicone tube tied on one end was threaded through the bye hole of the probe. Then the probe was reversed, pulling the dacron suture and the PICC tube through the uninvolved lacrimal punctum, so did the tube pass through the damaged punctum with the same method. The PICC tube was united end to end to form an annular stent with 6-0 nylon suture. The knot was cut short and rotated to the level of the common canaliculus or the lacrimal sac. At last, the two cut ends of the lacerated canaliculus were approximated with 8-0 Vicryl suture under the operating microscope and the skin edges were closed with interrupted 6-0 nylon suture.

Retrograde intubation using a modified pigtail probe The modified pigtail probe was first advanced into the punctum of the uninvolved canaliculus and rotated through the common canaliculus and out of the proximal end of the lacerated canaliculus. Next, a 6-0 nylon suture was placed in the hollow cavity of the probe and a segment of PICC silicone tube about 25 mm in length was then inserted reversely along the probe for more than a half of the hook. The probe was withdrawn back carefully, guiding the silicone tube as well as the nylon suture out of the punctum of the intact lacrimal system. Similar procedure was performed again for the guidance of the stent and nylon suture passed through the punctum and the distal portion of the severed canaliculus. Then the ends of the 6-0 nylon suture were tied off, uniting the silicone stent end to end. The knot was cut short and retracted within the stent, which was then rotated so that the knot site could be hidden in the common canaliculus. Other procedures were performed as mentioned above (Fig. 2). For the patients in whom common canaliculus could not be identified or conspicuous resistance was encountered, bicanalicular nasal intubation would be performed as an alternative.5

Postoperative care

After operation, the patients were given antibiotics and corticosteroid eye drops four times a day for 2 weeks. Eyelid suture was removed one week postoperatively. If no stent-related complications occurred, the stent was generally kept in the original place for 4-6 months. Scheduled follow-up lasted for 3-6 months after removal of the stent. Therapeutic effects of the reconstructed canaliculus were determined according to the criteria as follows: (1) Cure: free of epiphora and unobstructed lacrimal irrigation; (2) Improvement: little or relief of epiphora and unobstructed or insufficient smooth irrigation;
And (3) failure: epiphora and obstructed irrigation. All surgical data and follow-up outcomes were collected for retrospective analysis.

**Statistical analyses**

All statistical analyses were performed using software SPSS 11.0 for Windows (Chicago, USA). Chi-square test was used to examine the different success rates of searching cut ends in the two groups. Independent-samples t test was used to analyze the difference of operation time between the two groups. Mann-Whitney U test (belonging to nonparametric tests: two independent samples) was performed to determine the significance between the differences of therapeutic effects of the two groups.

![Fig. 1. Comparison between the traditional pigtail probe and the modified probe under operating microscope (×10). Above: The initial version of pigtail probe with a blunt end and an eye on the tip (with the diameter of 1.25 mm); Below: The modified probe with a smooth tip (with the outer-diameter of 0.50 mm). Its hollow cavity is shown in the lower right picture.](image)

![Fig. 2. Surgical procedures using the modified pigtail probe in canalicular repair. A: The probe passes through the superior punctum and the common canaliculus and out of the severed proximal end; B: A 6-0 nylon suture is inserted into the hollow cavity of the probe; C: The PICC silicone tube and the suture are inducted together by the withdrawal of the probe; D: The silicone tube passes through the superior punctum and is inducted out of the inferior punctum with the same method; E: Canalicular cut ends are repaired and the ends of the silicone tube are united to form an annular stent; F: Skin edges are closed with 6-0 nylon suture.](image)
RESULTS

In Group A, the proximal cut ends of the lacerated canaliculi were identified in 40 cases (97.56%), among which 27 (65.85%) were found successfully in the first attempt. False passages were found in 4 patients (9.76%). The mean time of searching the proximal cut ends of the canaliculi was $(11.40 \pm 3.35)$ minutes and the mean time of operation was $(45.33 \pm 5.12)$ minutes. In Group B, the proximal cut ends of the lacerated canaliculi were found in 45 cases (97.83%), among which 43 (93.48%) were found primarily. No false passage was found in this series. The mean time of searching the proximal cut ends of the canaliculi was $(5.02 \pm 2.73)$ minutes and the mean time of operation was $(33.90 \pm 4.84)$ minutes. As the primary success rates of searching the cut ends and the false passage-forming rates were concerned, statistical significances were found between the two groups ($P<0.01$ and $P<0.05$, respectively). The mean time of searching the proximal cut ends of the canaliculi and the mean time of operation in Group B were both notably shorter than those of Group A ($P<0.01$), but no statistical significance was found between the total success rates of searching the cut ends of the two groups ($P>0.05$). Detailed statistical data are listed in Table 1 and Table 2. One patient in each group (2.30%) underwent bicanalicular nasal intubation because common canaliculi could not be identified in surgical procedures. After follow-up, the therapeutic effects were presented as cure in 37 patients, improvement in 1 and failure in 3 in Group A, with the cure rate of 90.24%. In Group B, 44 patients were cured, 1 was improved and 1 failed, with the cure rate of 95.65%. Though higher cure rate was achieved in the latter, no statistical significance was found between the two groups ($Z=1.007, P>0.05$).

Table 1. Comparison of success rates of searching cut ends and false passage-forming rates between the two groups ($n$, %)

<table>
<thead>
<tr>
<th>Groups</th>
<th>n</th>
<th>Primary success rates of searching cut ends</th>
<th>Total success rates of searching cut ends</th>
<th>Rate of false passages</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>41</td>
<td>27 (65.85%)</td>
<td>40 (97.56%)</td>
<td>4 (9.76%)</td>
</tr>
<tr>
<td>B</td>
<td>46</td>
<td>43 (93.48%)*</td>
<td>45 (97.83%)</td>
<td>0 (0%)*</td>
</tr>
</tbody>
</table>

$x^2$ 10.522 0.007 4.704

*P<0.01, *P<0.05, compared with Group A.

Table 2. Comparison of efficiency between the two groups ($\bar{x} \pm s$, min)

<table>
<thead>
<tr>
<th>Groups</th>
<th>n</th>
<th>Time of searching the proximal cut ends (min)</th>
<th>Time of operation (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>41</td>
<td>$11.40 \pm 3.35$</td>
<td>$45.33 \pm 5.12$</td>
</tr>
<tr>
<td>B</td>
<td>46</td>
<td>$5.02 \pm 2.73$*</td>
<td>$33.90 \pm 4.84$*</td>
</tr>
</tbody>
</table>

$t$ 9.779 10.700

*P<0.01, compared with Group A.

DISCUSSION

Identifying the proximal cut ends of the lacerated lacrimal canaliculi is a key step in the management of monocanalicular laceration. However, traumatic tissue edema, especially when the trauma has occurred for a long time or severe laceration is present, often induces the proximal cut ends of the lacerated canaliculi to recess into the orbicularis oculi muscle, which will obscure the anatomic landmark for surgery and disturb the searching course. Moreover, increased difficulty and duration of surgical procedures may aggravate the iatrogenic damage and lessen the cure rate.

A single canalicular laceration, superior or inferior, can be managed with monocanalicular or bicanalicular intubation. Pigtail probes have been widely used as an efficient instrument for searching the proximal cut ends in the management of bicanalicular intubation since it was first reported by Worst in 1962. Whereas Jones reported that a common canaliculus was absent in up to 10% normal individuals and the canaliculi entered the lacrimal sac separately, which resulted in the assumption that the chance of iatrogenic complication such as forming false passages would surpass 10% when the pigtail probe was employed in the management of canalicular injury. This theory brought doubts and denials to the pigtail probe and led to its decreasing use directly. As it was revealed in a survey by Ho and his associates that only 2.2% ophthalmologists in the United Kingdom would routinely use pigtail probes, 39% would occasionally use this device and 57% would never consider using it. However, through
using digital dacryocystography, recent radiological studies showed that common canaliculus could not be identified in only 2.0% lacrimal drainage systems. Therefore, the risk of iatrogenic complications, if the pigtail probe was employed properly, would be far less than that speculated before.

The tip of the initial version of a pigtail probe was designed as a sharp hook, which was considered to be apt to cause complications such as false passages. Even the later modification of a blunt tip or eyelet drilled near the tip could not thoroughly avoid the risk of forming false passages. To our knowledge, the diameter of a pigtail or similar type probe is approximately 1.10-1.25 mm, but the intraluminal diameter of a normal canaliculus or common canaliculus is just 0.5-1.0 mm when in a relaxed state. This ductal difference will produce a relatively high resistance during the advance of the probe and the thrusting action of the probe encountering the resistance may become a main factor to form a false passage. We have modified the caliber of the traditional pigtail probe to 0.50 mm, which allows its smooth advance through the lacrimal passage and minimizes the risk of forming a false passage. The outer diameter of the modified probe was also especially fit for the inner diameter of the PICC silicone stent (with the inner diameter of 0.51 mm) that we used. Compactely sheathing the PICC stent over the probe could effectively avoid the potential detachment during their withdrawal. Furthermore, due to the hollow cavus of the modified probe, the nylon suture to unite the stent could be directly inducted accompanying the stent without using the guiding thread mentioned previously. The simplified manipulation minimized irritations or damages to the traumatic tissues and favored the healing of the cut ends or pericanalicular tissues. All these procedures would hence enhance the efficiency and the success rate of canalicular reconstructions. Compared with the procedure using the traditional pigtail probe, both of the time of identifying the cut ends and the time of operation using the modified pigtail probe were widely shortened and the primary success rate of searching the cut ends was also significantly enhanced. Furthermore, this method was especially efficient for the patients with the lacerated canaliculus close to the lacrimal sac or with difficulty in treating them with traditional approaches. In our series, only two patients (2.30%) were found absent of a common canalicular. Though the cases in this study are not sufficient enough, our result corroborates Yazici’s conclusion indirectly and yet needs to be confirmed by further prospective investigations.

In conclusion, retrograde intubation using pigtail probe is a convenient and efficient method for identifying the proximal cut ends in the management of monocanalicular laceration. Radiological improvements will provide substantial proofs for the reanimation of the pigtail probe. Our promising result supports that necessary or proper modifications to the pigtail probe can minimize the risk of iatrogenic complications and enhance the efficiency and therapeutic effects of reconstruction of lacerated canaliculus.

REFERENCES


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