Rejuvenation of the deep superior sulcus in the eyelid

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Summary

Background Nowadays, a number of patients seeking cosmetic surgery for their sunken upper eyelid are increasing. The aim of this study was to provide an overview of the various treatment options for sunken superior sulcus with reported complications and to discuss effective methods for treatment.

Methods In a PubMed search, studies involving patients undergoing correction of sunken superior sulcus with various treatment options were included.

Results A systematic search revealed twelve articles representing 680 cases that satisfied inclusion criteria. All were case series, and no randomized controlled studies were found. Five reported on augmentation of the deformity with surgery, while hyaluronic acid filler was used in four reports. There was a report attempting to correct the deformity by the microautologous fat grafting. The combined surgical approaches including ptosis correction with upper blepharoplasty and appropriate fat grafting were used in two reports. About 7.2% of patients (49/680) experienced complications, with 4.3% requiring re-operation, while no severe complications were observed.

Conclusions By careful identification of the clinical features and proper classification of the types of sunken superior sulcus, the treatment plan can be specified.

Keywords: sunken eyelid, sunken superior sulcus, review

Introduction

As life expectancy is rising and life quality improving, the desire to rejuvenate the aging face is constantly increasing. The periorbital area is considered to be the first area capturing one’s attention. For this reason, rejuvenation of this anatomical area has also gained in popularity. In one’s youth, most eyelids are full and rarely hollow, while atrophied periorbital tissue with a loss of skin elasticity is a typical change in aged upper eyelids.

Sunken superior sulcus refers to a deformity resulting in a depression between the lower eyebrow and upper border of the globe, regardless of the cause. This is also called sunken upper eyelid, upper eyelid hollowing, superior sulcus syndrome, or sunken superior sulcus.

Several reports of the treatment of sunken superior sulcus have been described in the medical literature. Autologous fat grafting, dermal filler injection, and various surgical methods are available. To the best of the authors’ knowledge, however, there have been no systematic reports analyzing the treatment options for sunken superior sulcus. The aim of this report was to give an overview of the various treatment options for sunken upper eyelid with reported complications and to discuss effective methods for treatment.
Patients and methods

Literature search

The systematic review was performed in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analysis guidelines (Fig. 1). A computerized search of the PubMed database was performed independently by the authors. The following search terms and Boolean operators were used to include related terms: “sunken upper eyelid” OR “superior sulcus deformity” OR “upper eyelid hollowing” OR “sunken superior sulcus”. The reference list of the returned articles was further screened to retrieve relevant studies.

Eligibility criteria

The inclusion criteria consisted of any case series or case report involving patients undergoing correction of sunken upper eyelid deformity with surgery, filler injection, or fat graft. Exclusion criteria were case reports and series with fewer than three patients in total, letters and comments, and non-English-language articles. Articles were also excluded if correction of sunken superior sulcus was performed for reconstructive purposes in anophthalmic condition. Duplicated articles or articles using a duplicate patient sample were not considered.

Study selection

Citations found through the literature database search and reference screening were title- and/or abstract-reviewed for eligibility. A total of 133 citations were identified. After eliminating duplicates, abstracts were reviewed for the remaining 114 articles based on predefined inclusion and exclusion criteria. A total of 22 articles satisfied the aforementioned criteria in the abstract review process, and their full text was reviewed. Finally, 12 articles were included into the systematic review.

Data collection process

Data were extracted from the articles by the authors and reviewed, with any differences reconciled by discussion. Data fields were predetermined to include study descriptive data such as author, date of publication, study design, number of patients, mean age, mean fat or filler injection volume, average number of injections per patient, surgical technique, follow-up, patient satisfaction rates, and complications. The extracted data were listed separately by two independent reviewers. Discrepancies in data extraction were reviewed by all reviewers and discussed until consensus was reached.

Assessment of study quality

The quality of the studies was scored according to the Oxford Centre for Evidence-based Medicine (OCEBM) 2011 by two independent reviewers. Discrepancies in scoring were discussed by all reviewers.

Results

The 12 articles representing 680 cases were reviewed (Table 1): one had prospective characteristics and the remaining 11 articles were retrospective. Of the twelve studies, five examined isolated volume augmentation with fat graft or hyaluronic acid (HA) filler injection, while the remaining studies also addressed correction by surgery with or without fat graft. The extracted data are summarized descriptively in Tables 1 and 2 and Figures 1 and 2. The prevalence of complications was determined. Meta-analysis was not conducted due to the heterogeneous methodology demonstrated between the articles.
Augmentation of sunken superior sulcus with surgery

Thirteen patients with sunken upper eyelid underwent fascia–fat composite grafts in a study by Lee et al. All patients had received prior blepharoplasty. After the scar tissue release and ptosis correction, if necessary, about ten percent of intentional overcorrection was done as substitute for deficient postseptal fat. All patients were satisfied, and no other complication was reported except transient epiphora.

Frileck et al. investigated the efficacy and safety of correction of the deformity using a lumbrical fat graft. After muscle-sparing skin excision in blepharoplasty, lumbrical-shaped deep fat from the abdomen or pubic region was placed within the septal space. The overcorrection was not necessary due to excellent graft survival. The authors found that patients were satisfied with their improvement with the exception of one patient. Minor revisions were performed in five cases, four cases for graft excess, and one case for contour irregularity, respectively.

Maniglia et al. reported surgical treatment of sunken upper eyelids in 30 patients. Through upper eyelid incision, the periosteal flap was elevated from 10 mm above the orbital rim and turned downward. There was one case of undercorrection with eyelid retraction, which was treated with a temporalis fascia graft.

Table 1 Characteristics of included studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Year</th>
<th>Study design</th>
<th>Evidence level*</th>
<th>Number of patients</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lee et al.</td>
<td>2001</td>
<td>Case series</td>
<td>IV</td>
<td>13</td>
</tr>
<tr>
<td>Frileck et al.</td>
<td>2002</td>
<td>Case series</td>
<td>IV</td>
<td>35</td>
</tr>
<tr>
<td>Maniglia et al.</td>
<td>2006</td>
<td>Case series</td>
<td>IV</td>
<td>30</td>
</tr>
<tr>
<td>Morley et al.</td>
<td>2009</td>
<td>Retrospective case series</td>
<td>IV</td>
<td>27</td>
</tr>
<tr>
<td>Liew et al.</td>
<td>2011</td>
<td>Case series</td>
<td>IV</td>
<td>36</td>
</tr>
<tr>
<td>Park et al.</td>
<td>2011</td>
<td>Retrospective case series</td>
<td>IV</td>
<td>50</td>
</tr>
<tr>
<td>Choi et al.</td>
<td>2011</td>
<td>Case series</td>
<td>IV</td>
<td>7</td>
</tr>
<tr>
<td>Leyngold et al.</td>
<td>2014</td>
<td>Prospective case series</td>
<td>IV</td>
<td>5</td>
</tr>
<tr>
<td>Jung et al.</td>
<td>2014</td>
<td>Retrospective case series</td>
<td>IV</td>
<td>53</td>
</tr>
<tr>
<td>Lin et al.</td>
<td>2014</td>
<td>Case series</td>
<td></td>
<td>168</td>
</tr>
<tr>
<td>Chen et al.</td>
<td>2015</td>
<td>Case series</td>
<td>IV</td>
<td>250</td>
</tr>
<tr>
<td>Czyz et al.</td>
<td>2015</td>
<td>Case series</td>
<td>IV</td>
<td>6</td>
</tr>
</tbody>
</table>

*Oxford Centre for Evidence-Based Medicine 2011 Levels of Evidence

Table 2 Overview of studies on the treatment of sunken superior sulcus

<table>
<thead>
<tr>
<th>Study</th>
<th>N</th>
<th>Mean age, years (range)</th>
<th>Method</th>
<th>Auxiliary method</th>
<th>Mean volume injected/eye, mL (range)</th>
<th>Outcomes</th>
<th>Mean follow-up (range)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lee et al.</td>
<td>13</td>
<td>N/A (30–48)</td>
<td>Fascia–fat composite graft</td>
<td>Ptosis correction UB</td>
<td>N/A</td>
<td>All satisfied</td>
<td>2.5 Y</td>
</tr>
<tr>
<td>Frileck et al.</td>
<td>35</td>
<td>N/A</td>
<td>Lumbral fat graft</td>
<td>UB</td>
<td>N/A</td>
<td>34 PTS satisfactory</td>
<td>N/A</td>
</tr>
<tr>
<td>Maniglia et al.</td>
<td>30</td>
<td>N/A</td>
<td>Periosteal flap</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Morley et al.</td>
<td>27</td>
<td>51 (24–65)</td>
<td>HA filler</td>
<td>N/A</td>
<td>0.4 (0.1–1)</td>
<td>96% satisfactory, 85% improvement</td>
<td>13 M</td>
</tr>
<tr>
<td>Liew et al.</td>
<td>36</td>
<td>N/A</td>
<td>HA filler</td>
<td>N/A</td>
<td>N/A (0.2–0.6)</td>
<td>N/A</td>
<td>N/A (3 M–3.5 Y)</td>
</tr>
<tr>
<td>Park et al.</td>
<td>50</td>
<td>N/A (24–67)</td>
<td>Septal fat reposition</td>
<td>Ptosis correction, ROOF fat graft</td>
<td>1.4</td>
<td>46 PTS satisfactory</td>
<td>4.7 M (2–18 M)</td>
</tr>
<tr>
<td>Choi et al.</td>
<td>7</td>
<td>43.1 (28–60)</td>
<td>HA filler</td>
<td>N/A</td>
<td>0.61</td>
<td>All satisfied</td>
<td>9.6 M (3–18 M)</td>
</tr>
<tr>
<td>Leyngold et al.</td>
<td>5</td>
<td>68 (57–85)</td>
<td>HA filler</td>
<td>N/A</td>
<td>R 1 (0.5–1.3), L 0.8 (0.5–1), 0.7 (0.1–2)</td>
<td>All improved</td>
<td>9.5 M (6–13 M)</td>
</tr>
<tr>
<td>Jung et al.</td>
<td>53</td>
<td>41 (23–76)</td>
<td>Fat graft</td>
<td>Ptosis correction, UB</td>
<td>N/A</td>
<td>Satisfactory</td>
<td>4 M (2–24 M)</td>
</tr>
<tr>
<td>Lin et al.</td>
<td>168</td>
<td>35.5 (26–52)</td>
<td>Fat graft</td>
<td>N/A</td>
<td>R 1.8 (1.2–2.3), L 1.7 (0.8–2.4)</td>
<td>167 PTS satisfactory</td>
<td>N/A</td>
</tr>
<tr>
<td>Chen et al.</td>
<td>250</td>
<td>28 (19–36)</td>
<td>Septal fat reposition</td>
<td>UB</td>
<td>N/A</td>
<td>76% satisfactory</td>
<td>15 M (1–5 Y)</td>
</tr>
<tr>
<td>Czyz et al.</td>
<td>6</td>
<td>63 (46–81)</td>
<td>Dermofat graft</td>
<td>UB</td>
<td>N/A</td>
<td>Excellent</td>
<td>50.6 M (44.3–54.5 M)</td>
</tr>
</tbody>
</table>

N, number of patients; N/A, not applicable; Y, year; M, month; UB, upper blepharoplasty; HA, hyaluronic acid; PTS, patients; ROOF, retro-orbicularis oculus fat; R, right; L, left.
Chen et al.\textsuperscript{4} detailed their experience with a minimally invasive double-eyelid procedure with septal fat pad repositioning in 250 patients over a 5-year period. Patients were included in the study if they had sunken eyes and a positive result of lower eyelid compression test. A small incision (<1 cm long) was made along the center of the expected supratarsal fold. The pre-aponeurotic space was widely undermined, and the septal fat was mobilized to the depressed area without tension. The authors found that the overall satisfaction rate was 76%. While the minor complication rate was 8%, it was not significant.

Czyz et al.\textsuperscript{5} reported the results of volumetric augmentation using a dermis fat graft. Through a lid crease incision, the orbital septum was opened to expose pre-aponeurotic fat. Approximately 20–30\% oversized dermofat was harvested and was placed with the dermis facing superficially and the fat in apposition to the pre-aponeurotic fat. Concurrent ptosis surgery or blepharoplasty was performed, if necessary. The authors state that they treated six patients with “excellent” results and no reported complications.

Nonsurgical volume correction with HA filler injection

Morley et al.\textsuperscript{6} reported the outcomes of twenty-seven patients who underwent injection of HA gel to the sunken eyes. Multiple small aliquots (0.1 cc) of HA filler were injected in the preperiosteal plane. The mean injection volume was 0.4 cc per eye. During the mean follow-up of 13 months, five patients required additional injections, two patients underwent surgery due to unsatisfactory outcomes, and 96% of the patients were satisfied with the results. The authors proposed that patients with sunken superior sulcus without marked sub-brow deflation or hooding were the best candidates for the procedure.

Thirty-six patients underwent HA filler injection in a study by Liew et al.\textsuperscript{7} HA filler was deposited through two to three entry sites using a 30-gauge needle at the supraperiosteal plane in a linear droplet fashion. The range of average injection volume was 0.2–0.6 cc per eye. The corrected volume remained effective through the longest follow-up period of 3.5 years, so additional injections were unnecessary. No major complications were noted except for one case of excess and three cases of lumpiness.

Choi et al.\textsuperscript{8} conducted a study to investigate the efficacy of HA filler in the treatment of sunken superior sulcus and lid crease asymmetry. HA filler was placed using a 30-gauge needle deep to the orbital septum for sunken superior sulcus or deep to the orbicularis oculi muscle for lid crease asymmetry. The mean injection volume was 0.61 cc per eye. Of the seven patients included this study, all had excellent improvement and were satisfied after the procedure. During the longest follow-up of 18 months, not only there was no need for re-injection, but volume was maintained as well. No major complications were noted.

Leyngold et al.\textsuperscript{9} examined the effectiveness of injecting HA filler in patients with lagophthalmos with sunken
superior sulcus in a prospective study. Of the five patients included in the study, all had lagophthalmos with deep superior sulcus and keratopathy. HA filler was injected with a 30-gauge needle deep to the orbital septum. The mean injection amount was 1.0 cc in the right eye and 0.8 cc in the left eye. The authors found that there was significant improvement in lagophthalmos (100%), keratopathy (80%), and superior sulcus appearance (80%). Volume maintenance of the injected HA filler was kept during the average follow-up of 9.5 months, except in 30% of cases that required additional injection. Two patients required one additional injection. There were no major complications.

**Isolated volume supplement with autologous fat graft**

In a recent study, Lin et al.\(^1\)\(^6\) presented their experience with microautologous fat grafts in 168 patients during a 3-year period. Fat was harvested with a 3-mm blunt cannula and centrifuged for 3 min at 3000 rpm as Coleman’s technique. A purified fat-filled 1-mL syringe was loaded into the Microautologous Fat Transplantation-Gun, and each injection volume was set at 1/240 mL to achieve optimal graft survival. With an 18-gauge blunt cannula, a fat parcel was transplanted in 3–4 layers, “deep layer above the inferior orbital rim,” “deep in the muscle,” and “just beneath the dermis.” The mean injection amount was 1.8 cc in the right eye and 1.7 cc in the left eye. No major complications were experienced. Except for one patient who underwent re-injection, the rest were all satisfied.

**Correction of sunken superior sulcus with combined methods**

Park et al.\(^1\)\(^1\)\(^1\) reported on septal fat repositioning combined with fat graft to retro-orbicularis oculus fat (ROOF). They achieved a significant improvement in sunken deformity by ptosis correction alone or in combination with orbital fat relocation. The remaining deformity was treated using ROOF fat graft. The mean graft volume was 1.4 cc per eye. During the mean follow-up period of 4.7 months, two patients required one additional injection. Their results showed that overcorrection is necessary in about 20–30% of cases. Of the fifty patients included in this study, 46 accomplished a satisfactory result. No major complication was noted except for two cases of lumpiness and two cases of undercorrection.

Jung et al.\(^1\)\(^2\) reported on combined surgical methods that include fat grafting with blepharoplasty or blepharoptosis correction in 53 patients. The authors classified the type of deformity into two groups. In the first group, 45 patients who needed correction of sunken eyelid only, a mean volume of 0.7 cc per eye of fat graft was injected in the suborbicularis oculi plane. The other group, patients who needed concurrent corrective surgery, had a mean volume of 0.5 cc per eye of fat grafted in the intraseptal plane. Secondary fat grafting at a mean volume of 0.5 cc per eye was completed in 32% of patients. The authors found that there were satisfactory outcomes without any major complications.

**Discussion**

Generally, attractive, youthful-looking eyes share some characteristics. First, three quarters of the cornea should be exposed, with the upper limbus covered by upper eyelid about 1.5–3 mm. Upon eye opening, the ratio of the distance between the lowermost eyebrow and the lid margin to the exposed pretarsal skin is more than three to one. In addition, there is convexity and fullness in the lid–brow junction. In contrast, the aging eyelid, especially in sunken superior sulcus, shows unique pathologic features. The patients complain of looking old, tired, and cheerless, which is usually more severe in the afternoon. Multiple folds due to skin excess may be accompanied as well (Fig. 2).\(^1\)\(^3\),\(^1\)\(^4\)

Functional deficits in addition to cosmetic issues may occur, such as blepharoptosis, lagophthalmos, or even corneal erosion.\(^1\)\(^5\)

The pathogenesis of sunken upper eyelid is multifactorial. The deformity is caused by the disproportion between a prominent orbital bony framework and underdeveloped soft tissue, congenitally. It can also be caused by either trauma, excessive fat removal after blepharoplasty, or senile changes.\(^3\),\(^1\)\(^6\) In the cases of senile sunken superior sulcus, weakening of Lockwood’s ligament may play a major role.\(^1\)\(^7\),\(^1\)\(^8\) As the ligament weakens, the lower septal fat bulges and the upper septal fat transposes superoposteriorly. This is called the Rouleau phenomenon, which corresponds to the observation in MRI.\(^1\)\(^9\) Unbalanced bony absorption is also known to be associated with this entity. A radiologic study revealed that the orbital aperture in this area increases with age.\(^2\)\(^0\) In addition, levator dehiscence from the tarsal plate and relative intact its dermal insertion make blepharoptosis with high fold\(^1\)\(^3\) (Fig. 3).

To volumize atrophied fat component only, the surgical approaches such as dermofat graft,\(^5\) fascial fat graft,\(^1\) lumbrical fat graft,\(^2\) and even periosteal flap\(^3\)
are available (Fig. 4). Also, there is a report of successful experience using acellular dermal allograft. In the presence of blepharoptosis, the sunken deformity would be improved using septal fat reposition with ptosis correction. Nonincisional blepharoplasty combined with transconjunctival levator–Müller complex tucking would also correct sunken superior sulcus based on clinical experiences by many plastic and dermatologic surgeons. This is believed to occur because the patient’s own soft tissue including pre-aponeurotic fat is moved up toward the depressed area by tightening the levator complex.

The fundamental approach may be ptosis correction with upper blepharoplasty and appropriate fat grafting. This is an ideal choice for patients who have a significant volume deficit with definite dermatochalasis and blepharoptosis (Fig. 5). Treatment with just overfilling without skin excision in the presence of definite dermatochalasis results in unnatural appearance and consequently unsatisfactory outcome. The amount of skin excision is determined based on the final postoperative skin envelope to be expanded to 80–90% compared with the previous state. In other words, skin excision should be performed conservatively or it may cause esthetically unnatural appearance. Orbicularis oculi muscle should be preserved as much as possible not only to supplement volume deficit, but also to prevent multiple folds and depressed scar. It is generally believed that the number of stem cells in the nasal fat pad is higher than in the pre-aponeurotic fat pad. Accordingly, the nasal fat pad tends to be more resistant to senile atrophy. Thus, the correction of sunken deformity would be done using the relatively prominent nasal fat pad and by repositioning of the posterosuperiorly dislocated septal fat. Septal fat repositioning can provide an appropriate gliding plane and can be performed for the purpose of preventing multiple folds, as well as augmenting volume.

When complete correction of the sunken deformity is not possible just using adjacent fatty tissue, many surgeons prefer to perform fat grafting into the ROOF or the corresponding layer. The degree of correction of blepharoptosis is related to the volume grafted and the condition of levator muscle. Furthermore, there may be some racial differences in the condition of levator aponeurosis. According to a recent report, involutional ptosis results mainly from disinsertion of aponeurosis from the tarsal plate in Caucasians, while the decreased levator function with fatty infiltration is found in Korean patients. Thus, blepharoptosis should be repaired with the consideration of these racial differences.

Figure 3  Etiology of sunken superior sulcus in the setting of senile change. (Above, left) Unbalanced absorption of orbital rim increases orbital aperture with aging. (Above, right) Periorbital fat atrophy, levator dehiscence from tarsal plate, and relative intact its dermal insertion make blepharoptosis with high fold. (Below, right) As a resultant of weakening of the Lockwood’s ligament, the lower septal fat bulges and the upper septal fat transposes superoposteriorly.
In the absence of definite dermatochalasis, patients with sunken superior sulcus may benefit from HA filler injection or fat graft. Subcutaneous fat in the facial region is divided into multiple superficial and deep fat compartments. Likewise, the upper peri-orbital fat compartment is composed of superficial “superior...
orbital fat compartment” and deep “ROOF compartment”. Each compartment ages independently. Because the upper eyelid skin and superior orbital fat compartment are thin, lumps or irregularities can easily occur when injecting at this plane. Table 3 showed that most of the procedures were performed at the intraseptal/retroseptal plane. This is reasonable because the aging process causes atrophy of the pre-aponeurotic fat pad. However, surgeons should be cautious not to injure any gliding system, resulting in adhesion at this plane. Thus, we believe that it is more desirable to inject HA filler or fat in the ROOF or the corresponding layer even though it is controversial.

Based on this review and our clinical experiences, the longevity of HA filler and fat graft performed at peri-orbital area is quite remarkable compared with that performed at other facial regions. Although the exact cause is unclear, this may be attributed to the relative lack of mobility of overlying muscle. Thus, clinicians should take great caution not to overcorrect the deformity. Technically, we advocate that the majority of the injection is placed not too inferiorly relative to the most depressed area without abrupt contour change. Also, the fat graft should be performed with evenly small particles to increase its graft survival. Otherwise, we recommend that the HA filler is injected as a confluent mass using the depot technique. This makes it easier to dissolve with hyaluronidase for later correction, if necessary, and may increase longevity by reducing the contact area between the tissues.

Only three of the twelve studies selected on current review have attempted to classify the sunken superior sulcus. Park et al. considered the depth of depression with a numerical value. Morley et al. classified the type of sunken deformity based on the extent of depression and skin redundancy. Jung et al. clinically divided the group according to the absence or presence of a need for combined surgical procedures. In addition, even though excluded in our review, Liang et al. graded the severity of disease according to the width and location of an enlarged invaginated skin space. However, these classification criteria seem heterogeneous and rather subjective, which lacks a numerical value or have not fully considered both blepharoptosis and skin excess. Therefore, none of the classification criteria described in previous articles are sufficient to apply to the treatment of the wide spectrum of the sunken superior sulcus. By integrating and revising the previous classifications, we offer a clinical algorithm to guide surgical judgment in the treatment of sunken superior sulcus. This algorithm is outlined in Figure 6.

**Table 3 Overview of complications**

<table>
<thead>
<tr>
<th>Study</th>
<th>N</th>
<th>Graft/injection plane</th>
<th>Overcorrection</th>
<th>Secondary procedure</th>
<th>Number of complication</th>
<th>Type of complication (N)</th>
<th>Management</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lee et al. (2001)</td>
<td>13</td>
<td>Intraseptal</td>
<td>10%</td>
<td>N/A</td>
<td>4</td>
<td>Epiphora</td>
<td>Spontaneous resolved</td>
</tr>
<tr>
<td>Frileck et al. (2002)</td>
<td>35</td>
<td>Intraseptal</td>
<td>Unnecessary</td>
<td>N/A</td>
<td>7</td>
<td>OC (4)</td>
<td>Revision</td>
</tr>
<tr>
<td>Maniglia et al. (2006)</td>
<td>30</td>
<td>SubOOM</td>
<td>N/A</td>
<td>N/A</td>
<td>1</td>
<td>UC (1)</td>
<td>Temporalsis fascia graft correction (2)</td>
</tr>
<tr>
<td>Morley et al. (2009)</td>
<td>27</td>
<td>SubOOM, preperiosept</td>
<td>N/A</td>
<td>5</td>
<td>2</td>
<td>Unfavorable result (2)</td>
<td>Dissolution (1) Massage (3) Revision</td>
</tr>
<tr>
<td>Liew et al. (2011)</td>
<td>36</td>
<td>Supraperiosept</td>
<td>Unnecessary</td>
<td>None</td>
<td>4</td>
<td>OC (1)</td>
<td>\</td>
</tr>
<tr>
<td>Park et al. (2011)</td>
<td>50</td>
<td>ROOF</td>
<td>20-30%</td>
<td>2</td>
<td>4</td>
<td>UC (2)</td>
<td>\</td>
</tr>
<tr>
<td>Choi et al. (2011)</td>
<td>7</td>
<td>Subseptum, retrosept</td>
<td>N/A</td>
<td>None</td>
<td>None</td>
<td>N/A</td>
<td>\</td>
</tr>
<tr>
<td>Leyngold et al. (2014)</td>
<td>5</td>
<td>Deep to septum</td>
<td>N/A</td>
<td>2</td>
<td>N/A</td>
<td>N/A</td>
<td>\</td>
</tr>
<tr>
<td>Jung et al. (2014)</td>
<td>53</td>
<td>Subseptum, intraseptal</td>
<td>N/A</td>
<td>17</td>
<td>6</td>
<td>Irregularity (2)</td>
<td>\</td>
</tr>
<tr>
<td>Lin et al. (2014)</td>
<td>168</td>
<td>Subdermal, Subseptum, preperiosept</td>
<td>Unnecessary</td>
<td>1</td>
<td>2</td>
<td>Transient ptosis (4)</td>
<td>\</td>
</tr>
<tr>
<td>Chen et al. (2015)</td>
<td>240</td>
<td>Subseptum</td>
<td>N/A</td>
<td>20</td>
<td>20</td>
<td>Others</td>
<td>Observation</td>
</tr>
<tr>
<td>Czyz et al. (2015)</td>
<td>6</td>
<td>Intraseptal</td>
<td>20-30%</td>
<td>N/A</td>
<td>None</td>
<td>N/A</td>
<td>\</td>
</tr>
</tbody>
</table>

N, number of patients; N/A, not applicable; OC, overcorrection; UC, undercorrection; ROOF, retro-orbicularis oculus fat; FG, fat graft; Others, suture extrusion, hematoma, mild fold asymmetry, temporary chemosis.
Current investigation showed that various complications can occur during the correction of sunken superior sulcus. The summary of complications is listed in Table 3 and Figure 7. About 7.2% of patients (49/680) experienced complications, with 4.3% requiring re-operation, as calculated from the articles included in this review. The most frequently seen complication was lump or irregularity. Overcorrection should be avoided especially in the case of fat graft, because once injected it cannot be easily removed. No severe complications such as infection, tissue necrosis, or vascular obstruction were observed. However, according to the previous report, there are 29 articles describing 32 patients where visual impairment was identified due to embolism after cosmetic injection.34 The position of vascular arcade, responsible for blindness, is found mostly in the superficial subcutaneous layer.35 Hence, it is necessary to pay special attention to injection along a relatively avascular plane. Some physicians have advocated the use of a blunt cannula, because it may prevent an intravascular injection. However, blindness may also occur in cases using a cannula despite its extreme rarity.34 In our opinion, although it is controversial, the retrograde and resistance-free injection under low pressure is the most important.7,36,37 Therefore, we prefer using relatively large-caliber (23 gauge or larger) needles for this procedure.

There are several limitations to this investigation. Most of the studies are retrospective, and only one prospective study was included. Thus, all articles used in this review were considered with a high-risk bias and no randomized controlled studies were found. The heterogeneity regarding study patient demographics and follow-up period makes comparisons via a meta-analysis technique impractical and systematic review difficult. Lastly, bearing in mind the variation in lid anatomy between the Caucasian and Oriental eyelids, further studies may be beneficial in searching for the best possible management according to racial
differences. Finally, it is very important to recognize that this is only a rough guide for the physicians and that clinical knowledge and experience should always be incorporated in therapeutic planning for the correction of sunken superior sulcus.

References


