Suture loop myopexy versus silicone band loop myopexy in the management of myopic strabismus fixus

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PURPOSE
To compare two different modalities of superior rectus–lateral rectus loop myopexy; suture (SLM) and silicone band loop (SBM), in the treatment of myopic strabismus fixus.

METHODS
The medical records of patients with myopic strabismus fixus who underwent surgical management with either SLM or SBM at a single institution over a period of 4 years were retrospectively reviewed. In cases with positive intraoperative forced duction test, the medial rectus muscle was recessed. The primary outcome measures were improvement of primary position esotropia, hypotropia, and limitations of abduction and elevation. The angle between the displaced superior rectus and lateral rectus muscles (angle of globe dislocation) was also assessed by orbital imaging before and after surgery.

RESULTS
A total of 21 patients were identified, of whom 10 underwent SLM and 11 underwent SBM. Mean age at surgery was 65.4 ± 5.7 years in the SLM group and 68.5 ± 6.4 years in the SBM group. Both procedures significantly improved esotropia, hypotropia, angle of globe dislocation, and limitation of abduction and elevation (P < 0.0001), with no significant statistical difference between procedures (P > 0.05). Intraoperative muscle splitting occurred in 2 cases in the SLM group, and transient foreign body sensation was documented in 3 cases in the SBM group.

CONCLUSIONS
In this study cohort, both techniques achieved significant correction of ocular deviation, limitation of ocular ductions, and angle of globe dislocation associated with myopic strabismus fixus, with no statistically significant difference between procedures. Operative complications in both groups were mild and innocuous. (J AAPOS 2020;24:276.e1-6)

Myopic strabismus fixus is a rare form of restrictive strabismus in highly myopic eyes characterized by slowly progressive, large-angle esotropia and hypotropia associated with severe degrees of limitation of ocular ductions, especially abduction and elevation. The pathogenesis of myopic strabismus fixus was not clearly understood until Krzizok and Schroeder and Yokoyama and colleagues discovered temporal herniation of the posterior part of the globe outside the extraocular muscle cone on magnetic resonance imaging (MRI) as a result of myopic progressive axial elongation. Such herniation would result in the downward displacement of the lateral rectus and nasal displacement of the superior rectus muscles, leading to limitation of abduction and elevation, with exaggeration of adduction and depression.

In the past, a conventional rectus muscle recession-resection procedure was used to manage myopic strabismus fixus and was associated with high rates of significant undercorrection and recurrence. Understanding the pathophysiology has led to the development of surgical techniques to address the cause of the condition. Currently, closure of the muscle cone gap between superior rectus and lateral rectus muscles by muscle union or loop myopexy is the procedure of choice. Muscle loop myopexy can be performed using nonabsorbable sutures, either with a single suture or a two- or three-suture technique, or using a silicone band. The current study compares suture loop myopexy (SLM) with silicone band loop myopexy (SBM) in the management of myopic strabismus fixus in terms of correction of esotropia, hypotropia, angle of globe dislocation, and limitation of ocular ductions.

Subjects and Methods
This study adhered to the tenets of the Declaration of Helsinki and was approved by the Benha University Institutional Review Board. The medical records of consecutive patients with myopic strabismus fixus who underwent SLM or SBM at Benha University Hospital between January 2015 and February 2019 were retrospectively reviewed. Patients with a clinical diagnosis of...
myopic strabismus fixus characterized by slowly progressive large-angle esotropia and hypotropia associated with limited abduction and elevation in highly myopic eyes and at least 6 months of postoperative follow-up were included. Patients with neurological or developmental disorders were excluded, as were those who underwent previous extraocular muscle surgery. Preoperatively, all patients underwent a comprehensive ophthalmic and orthoptic examination, including refraction, corrected visual acuity, fundus examination, and axial length measurement using A-scan biometry. Angle of deviation in the primary position was measured by prism cover test. The Krimsky test was used in cases with restricted refixation movements. Limitation of ocular motility was assessed using a 6-point scale.10

Before surgery and at 1 month postoperatively, all patients underwent orbital imaging: coronal computed tomography or MRI with a slice thickness of 3 mm. Extraocular muscle path abnormalities were analyzed and documented according to the protocol published by Krzizok and Schroeder.2 Quantitative assessment of the relation between superior rectus and lateral rectus muscle bellies and the center of the globe was performed following Yama-gushi and colleagues.8 The angle of dislocation of the globe was defined as the angle suspended between the center of both the superior rectus and lateral rectus muscle and centroid of the globe on orbital imaging using a software protractor. At each follow-up examination, the angle of ocular deviation and limitation of ocular ductions were assessed. Results of the last examination was used for analysis and comparison.

Basic surgical steps in both groups were nearly identical. Under general anesthesia, forced duction testing was performed first, and in cases of positive contracture of medial rectus muscle, the muscle was conventionally recessed by an amount sufficient to relieve the contracture. A superior-temporal fornix conjunctival incision was performed to gain access to superior rectus and lateral rectus muscles. Both muscles were isolated, hooked, and cleaned from surrounding fascia attachments, and care was taken to avoid inclusion of the superior oblique muscle during isolation of superior rectus muscle. In the SLM group, the gap between the superior rectus muscle and the lateral rectus muscle was identified, and both muscles were approximated to each other using three interrupted nonabsorbable 5-0 polyester sutures placed retroequatorially, as described by Farid and colleagues.10 In the SBM group, a type 240 silicone band (Mira, Uxbridge, MA) was passed under the superior oblique muscle during isolation of superior rectus muscle and lateral rectus muscle together by pulling the two ends in opposite directions. The ends of the silicone band were cut close to the edge of the sleeve. Finally, the conjunctiva was closed using interrupted 7-0 polyglactin 910 sutures.

The main outcome measures were change in primary position esotropia, hypotropia, limitation of ocular abduction and elevation, and effect of surgery on angle of displacement of the superior rectus muscle and lateral rectus muscle on orbital imaging.

Statistical analyses were performed using SPSS software, version 17.0 (SPSS Inc, Chicago, IL) and parameters were compared using the t test, with a P value of <0.05 considered statistically significant.

Results
A total of 37 eyes of 21 patients underwent surgical correction of myopic strabismus fixus and met inclusion criteria: 18 eyes of 10 patients in the SLM group and 19 eyes of 11 patients in the SBM group. The average time of postoperative follow-up was 10.3 months for the SLM group and 11.8 months for the SBM group. Mean age of patients at time of surgical correction of myopic strabismus fixus was 65.4 ± 5.7 years (range, 55-72) in SLM group and 68.8 ± 6.4 years (range, 59-78) in SBM group. Of the 10 patients in the SLM group, 2 had unilateral myopic strabismus fixus and 8 had bilateral myopic strabismus fixus. Of the 11 patients in the SBM group, 3 had unilateral myopic strabismus fixus and 8 had bilateral myopic strabismus fixus.

The average spherical equivalent refractive error, measured in phakic eyes only, was −12.6 ± 3.06 D in the SLM group (14 eyes) and −15.1 ± 3.1 D in the SBM group (14 eyes). The average axial length was 29.5 ± 1.7 mm in the SLM group and 29.5 ± 1.7 mm in the in SBM group. The medial rectus muscle was recessed in 12 eyes in the SLM group (average, 7.8 ± 1.6 mm) and in 11 eyes of the SBM group (average, 7.5 ± 1.8 mm), based on results of intraoperative forced duction testing.

At the last postoperative visit, there was significant improvement of all study parameters in both groups (P < 0.0001). Following SLM, esotropia and hypotropia improved from 92° and 20° to 4° and 0.5°, respectively; limitation of abduction and elevation were corrected from −5 and −3.1 to −1.2 and −1.1 units, respectively (Figure 1). Following SBM, esotropia and hypotropia improved from 96.8° and 20.4° to 5.9° and 2.2°, respectively, and limitation of abduction and elevation were corrected from −5.1 and −3.4 to −1.3 and −1.5 units, respectively (Figure 2). Angle of globe dislocation improved from 156° ± 9.5 and 160.5° ± 11.6 to 93.8° ± 10.5 and 95.2° ± 13.3 in the SLM and SBM groups, respectively (Figure 3).

In the SLM and SBM groups, the average improvement, respectively, of esotropia was 88° and 90.4°; of hypotropia, 19.5° and 18.1°; and of angle of globe dislocation, 62.7° and 65.2°. The average correction of limitation of abduction was 3.7 unit in both groups, and the average improvement of limitation of elevation was 1.9 units and 1.8 units in the SLM and SBM groups, respectively. In all parameters however, there was no significant difference between both procedures (P > 0.05). See Table 1.

Intraoperatively, there were 2 cases of muscle splitting during SLM, which were repaired immediately by suturing the split muscle with 6-0 polyglactin 910. Foreign body sensation was reported by 3 patients in the postoperative period in the SBM group. It did not, however, last more
than 2 months after surgery. No other intraoperative or postoperative complications were recorded in both groups.

**Discussion**

Management of myopic strabismus fixus has undergone a paradigm shift recently. Orbital imaging studies have revealed that posterior globe enlargement secondary to axial myopia causes its herniation through the temporal part of the intermuscular septum, with shifting of the extraocular muscles, mainly the superior rectus and lateral rectus muscles. This abnormal muscle path has been found responsible for development of esotropia and hypotropia, with associated limitation of ocular ductions, in myopic strabismus fixus. Since then, surgeons began to develop certain techniques tailored to precisely address the abnormal muscle paths of the superior rectus and lateral rectus muscles. Instead of a conventional horizontal rectus muscle recession-resection procedure, which was associated with high rates of undercorrections and recurrences, a muscle union procedure, or loop myopexy between the shifted superior rectus and lateral rectus muscles, has become the method of choice to treat myopic strabismus fixus. However, loop myopexy

![FIG 1](image1.png)

**FIG 1.** Clinical photographs of a patient with bilateral myopic strabismus fixus treated by suture loop myopexy. A, Before surgery the patient had an esotropia of 80° and hypotropia of 15°, with sever limitation of abduction and elevation. B, After surgery the patient had exotropia of 5° and hyper tropia of 5° in the primary position, with marked improvement in limitation of ocular ductions.

![FIG 2](image2.png)

**FIG 2.** Clinical photographs of a patient with bilateral myopic strabismus fixus treated by silicon band loop myopexy. A, Preoperatively the patient had an esotropia of 120° and a hypotropia of 25°, with sever limitation of abduction and elevation. B, Postoperatively the patient was orthotropic in the primary position, with marked improvement of limited ocular ductions.
techniques vary. Some surgeons, for example, use nonabsorbable sutures, either single \cite{8,9} or multiple \cite{10,11} whereas others use a silicone band \cite{12,13} to approximate the shifted and widely displaced muscles. In the current study, we performed a retrospective comparison of two different modalities of loop myopexy: multiple sutures loop myopexy and silicone band loop myopexy in treatment of myopic strabismus fixus. We found that both techniques greatly improve ocular deviations and limited ocular ductions, with no significant difference between results.

SLM has been performed using nonabsorbable sutures, either as single suture loop myopexy \cite{8,9} or as two-suture \cite{11} or three-suture \cite{10} loop myopexy. Some authors have performed SLM without scleral attachment, \cite{9,10,14-16} whereas

![Image](FIG 3. Angle of globe dislocation (AGD) on coronal magnetic resonance imaging in a patient with bilateral myopic strabismus fixus treated by suture loop myopexy (A) and on coronal computed tomography of another patient with bilateral myopic strabismus fixus treated by silicon band loop myopexy (B). Preoperative images are in the left column; postoperative, in the right column. Note, noticeable improvement of AGD following surgery with restoration of normal paths of superior rectus and lateral rectus muscles in both patients. C, centroid of the globe; LR, lateral rectus muscle; SR, superior rectus muscle.)

<table>
<thead>
<tr>
<th>Item</th>
<th>SLM(^a)</th>
<th>SBM(^a)</th>
<th>(P) value</th>
</tr>
</thead>
<tbody>
<tr>
<td>ET, PD (range)</td>
<td></td>
<td></td>
<td>0.375</td>
</tr>
<tr>
<td>Before surgery</td>
<td>92 ± 19.3 (65 to 120)</td>
<td>96.8 ± 19.9 (70 to 125)</td>
<td></td>
</tr>
<tr>
<td>After surgery</td>
<td>4 ± 6.1 (−5 to 10)</td>
<td>5.9 ± 8 (−5 to 20)</td>
<td></td>
</tr>
<tr>
<td>Change</td>
<td>88 ± 17.3</td>
<td>90.4 ± 17.5</td>
<td></td>
</tr>
<tr>
<td>HOT, PD (range)</td>
<td></td>
<td></td>
<td>0.268</td>
</tr>
<tr>
<td>Before surgery</td>
<td>20 ± 6.2 (10−30)</td>
<td>20.4 ± 6.5 (10 to 30)</td>
<td></td>
</tr>
<tr>
<td>After surgery</td>
<td>0.5 ± 4.3 (−5 to 5)</td>
<td>2.2 ± 5.1 (−5 to 10)</td>
<td></td>
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<tr>
<td>Change</td>
<td>19.5 ± 3.6</td>
<td>18.1 ± 5.6</td>
<td></td>
</tr>
<tr>
<td>Limited abduction, unit (range)</td>
<td></td>
<td></td>
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<tr>
<td>Before surgery</td>
<td>−5.0 ± 0.7 (−4 to −6)</td>
<td>−5.1 ± 0.8 (−3 to −6)</td>
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<tr>
<td>After surgery</td>
<td>−1.2 ± 0.5 (0 to −2)</td>
<td>−1.3 ± 0.5 (0 to −2)</td>
<td></td>
</tr>
<tr>
<td>Change</td>
<td>3.7 ± 0.6</td>
<td>3.7 ± 0.7</td>
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<tr>
<td>Limited elevation, unit (range)</td>
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<td>0.408</td>
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<tr>
<td>Before surgery</td>
<td>−3.1 ± 0.9 (−2 to −5)</td>
<td>−3.4 ± 1.1 (−2 to −5)</td>
<td></td>
</tr>
<tr>
<td>After surgery</td>
<td>−1.1 ± 0.6 (0 to −2)</td>
<td>−1.5 ± 0.7 (0 to −3)</td>
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<tr>
<td>Change</td>
<td>1.9 ± 0.6</td>
<td>1.8 ± 0.6</td>
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</tr>
<tr>
<td>AGD, degree (range)</td>
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<tr>
<td>Before surgery</td>
<td>156 ± 9.5 (140 to 175)</td>
<td>160.5 ± 11.6 (145 to 175)</td>
<td></td>
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<tr>
<td>After surgery</td>
<td>93.8 ± 10.5 (80 to 115)</td>
<td>95.2 ± 13.3 (75 to 120)</td>
<td></td>
</tr>
<tr>
<td>Change</td>
<td>62.7 ± 12</td>
<td>65.2 ± 9.9</td>
<td></td>
</tr>
</tbody>
</table>

\(^a\)Results are mean ± SD.

AGD, angle of globe dislocation; ET, esotropia; HOT, hypotropia; PD, prism diopter; SBM, silicon band myopexy group; SLM, suture loop myopexy group.

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**Table 1.** Pre- and postoperative values and degree of improvement of main study parameters in suture loop myopexy and silicon band myopexy groups.
others have performed the procedure with scleral attachment and found that scleral attachment has no effect on surgical outcomes. In previous reports, the average improvement of esotropia was 17°–82° of hypotropia, 8°–26°. In the SLM group of the current series, mean improvement of esotropia was 88° of hypotropia, 19°. Limitation of abduction and elevation were improved in the current series by a mean of 3.7 and 1.9 unit respectively. Comparatively, average improvement of limited abduction and elevation in previous reports ranged from 1.2 to 2.7 units and 1.0 to 1.7 unit, respectively. Average improvement of angle of globe dislocation in previous reports was between 77° and 132°, compared with 63° in the current series.

In general, complications of SLM are minimal, usually muscle splitting and temporary elevation of intraocular pressure. We had 2 cases of intraoperative muscle splitting, repaired immediately using 6-0 polyglactin 910 sutures with no postoperative consequences.

Silicone band has been used as an alternative method to approximate superior rectus and lateral rectus muscles because of intraoperative muscle splitting, strangulation of anterior segment circulation and the potential nonreversibility of SLM. In addition to previous case reports on SBM, Shenoy and colleagues reported their results using the technique on 26 eyes of 15 patients with myopic strabismus fixus. Average improvement of esotropia in their study was 62° of hypotropia, 8°. Average improvement of limitation of abduction and elevation was 1.4 and 1.6 units, respectively. Foreign body sensation, necessitating the removal of the silicone band, was reported in 2 patients. Compared with the study of Shenoy and colleagues, our SBM group achieved an average improvement in esotropia of 90° and in hypotropia of 18°, with average improvement in limitation of abduction of 3.7 units and in elevation of 1.8 units. Postoperative foreign body sensation occurred in 3 of our patients; the sensation was temporary, however, in our cases and resolved by the second postoperative month.

Discrepancies in average correction of deviation and limited ocular ductions between previous reports and the current series could be attributed to the gross variability of angle of deviation in primary position and degree of limited ocular duction at presentation. In previous reports and the current study, presenting esotropia varied between 22° and 102°, and hypotropia varied between 9° and 32°. Degree of limited abduction at presentation varied between −2.9 and −5.0 units, and degree of limited elevation varied between −2.4 and −5.0°. It is also worth noting that higher degrees of improvements of ocular deviation and limited ocular ductions were achieved in reports with higher degrees of preoperative ocular deviations and limitations of duction. Therefore, loop myopexy, either using suture or silicone band, seems to address all degrees of severity of myopic strabismus fixus. In other words, loop myopexy could be considered as a self-adjusting procedure that targets the abnormal muscle paths and corrects the abnormalities of myopic strabismus fixus regardless of severity, with minimal risk of postoperative overcorrections.

To our knowledge, this is the first comparison of the results of two different modalities of muscle loop myopexy in the management of myopic strabismus fixus. Despite this study’s limitations, including its retrospective nature, the small number of patients, and limited follow-up, it underscores the previously reported successful results of loop myopexy in the treatment of myopic strabismus fixus. Additionally, according to our results, we found no significant difference between SLM and SBM in correction of ocular deviation, limited ocular ductions, and degree of globe dislocation on orbital imaging. However, each technique is associated with specific complications, including intraoperative muscle splitting (SLM) and postoperative foreign body sensation (SBM). The choice of technique is a matter of surgeon preference and experience.

References