Systematic Review of the Surgical Treatment of Trachoma Trichiasis

By

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Abstract

Aim

We conducted a systematic review to investigate which surgical technique for treating trachomatous trichiasis resulted in the best surgical outcomes, including success and adverse event rates.

Methods

To investigate success rates of different techniques, we limited our search to clinical trials in trachoma endemic populations that included a comparison group. We used internal validity criteria to assess the quality of the randomized trials and discussed external validity based on the aspects most relevant to the goal of treating large numbers of people in trachoma endemic areas with non-ophthalmologist surgeons in community settings. We also hand searched the literature to investigate whether either of the most successful procedures were associated with more adverse events than the other.

Results

Three randomized trials comparing two or more techniques provide good evidence that the bilamellar tarsal rotation and tarsotomy (transverse tarsotomy and rotation) are among the most effective surgical techniques for trachomatous trichiasis and entropion. Two other randomized trials provide evidence that the bilamellar tarsal rotation is equally successful
when performed by non-ophthalmologists as by ophthalmologists, and that transverse tarsotomy and rotation is equally successful when performed by non-ophthalmologists in a community setting as when non-ophthalmologists perform it in a hospital setting. The one randomized trial comparing bilamellar tarsal rotation and transverse tarsotomy and rotation found that the former was associated with more adverse events than the latter, but the other randomized trials and case series reported a wide range of adverse event rates for both bilamellar tarsal rotation and transverse tarsotomy and rotation.

Conclusions

The five randomized trials reviewed provide evidence that the bilamellar tarsal rotation and the transverse tarsotomy and rotation are among the most effective techniques for non-ophthalmologists correcting trachomatous trichiasis and entropion. Randomized trials large enough to analyze differences in adverse event rates between these two techniques would help elucidate if one technique is superior to the other. Also, further use and evaluation of clinical grading systems of trichiasis and entropion may clarify whether recurrences of trichiasis and entropion result from continued infection and progressive scarring or from errors in surgical technique. Detailed clinical grading systems might also shed light on whether certain surgical techniques are best suited for specific severities of trichiasis or entropion.
I. Background

Chlamydia trachomatis causes trachoma, the leading cause of preventable blindness worldwide. Studies\(^1\),\(^2\) within the last ten years project that anywhere from three to six million people are blind from trachoma. Also, for every case of blindness, 1.3 to 2.9 cases of trachomatous low vision exist. Trachoma is endemic primarily in impoverished, rural areas of developing nations, especially in Sub-Saharan Africa, but also in parts of Central and South America, the Middle East, Asia, and Australia. In some nations, such as the Gambia and Morocco, trachomatous blindness has declined, probably because of improved sanitation, education, and health care.\(^3\),\(^4\)

Repeated trachomatous infections may cause scarring of the upper tarsal conjunctivae. If this scar tissue contracts, the upper lid turns in (entropion), pressing the eye lashes against the eyeball (trichiasis)\(^5\). The lashes repeatedly brush against the cornea, eventually causing corneal scarring and opacification. In addition to discomfort from the above process, blindness results if the corneal opacification occurs over the visual axis. A longitudinal study in the Gambia found that individuals with trichiasis were eight times more likely than those with conjunctival scarring alone to develop corneal opacity over a twelve-year period.\(^6\)

In 1997, the World Health Organization began the Global Elimination of Blinding Trachoma by 2020 program. The program focuses
on four main strategies: surgery, antibiotics, facial cleanliness and environmental hygiene, thus the acronym SAFE. Although the World Health Organization intends the SAFE strategy ultimately to eradicate trachoma, surgery remains the only intervention likely to prevent blindness in those who already have trichiasis or entropion.

Controversy exists regarding which surgical techniques for trachomatous trichiasis and entropion achieve the best outcomes. Many procedures are available, and there is a pressing need to treat large numbers of people with only minimal resources. Many countries have developed cost-saving strategies such as training non-physician ophthalmic workers to perform corrective surgeries. Such workers usually receive thorough training in one particular technique, so the success of that technique is critical.

Although there are many reviews of the SAFE strategy and its components, no previous reviews have systematically examined outcomes of different surgical interventions for trichiasis and entropion. We conducted a systematic review to assess which surgical technique most effectively remedies trichiasis and entropion with the fewest associated adverse events. In addition, we investigated whether the literature presents one technique as the most accessible to non-ophthalmologist surgeons.
II. Methods

Randomized Trials of Surgical Techniques

We searched Medline and Cochrane Database of systematic reviews using the key words: "trachoma and trichiasis and surgery." We limited our search to clinical trials published in the English language between January 1950 and March 2004. We hand searched the reference sections of the included articles to locate additional trials meeting our criteria, but found none.

A primary and secondary reader evaluated every article retrieved by the above search for inclusion in the analysis. To be included, studies must have 1) performed a surgical intervention on the upper eyelid, 2) addressed a patient population in which entropion/trichiasis results from trachoma 3) included a comparison group (either control or other surgical technique), and 4) assessed the outcome of such interventions at least 3 months after the intervention. We excluded studies if they were 1) written in a language other than English 2) case reports or case series 3) non-human studies, and 4) review articles.

The Medline search yielded nine articles, five of which met the selection criteria. Three21-23 did not examine surgical interventions and one24 did not include a comparison group. Table 1 summarizes the selected randomized trials25-28, including location, date, surgical techniques, number of operations, provider type, length of follow-up, success rate, and effect on visual acuity.
We assessed the internal validity of the randomized trials using the following criteria: 1) adequacy of randomization, 2) intention to treat analysis 3) concomitant treatments described (i.e. antibiotics) 4) drop-out rates, 5) length of follow-up, 6) clear description of outcomes and 7) masking of outcome assessment. We assessed external validity based on subject demographics, provider type (surgeon, resident, ophthalmic nurse/assistant), and practicality of performing surgical techniques in a location with few resources. A study with strong external validity would treat patients in a trachoma endemic area, employ ophthalmic assistants rather than ophthalmologists, and perform the operations in community settings.

Studies of adverse events

The initial search and analysis resulted in two surgical techniques, bilamellar tarsal rotation and tarsotomy (transverse tarsotomy and rotation), with apparently equal success rates, but perhaps with different rates of adverse events. To collect more information on the adverse event rates of these two techniques, we searched for case series that 1) examined one of the two techniques: bilamellar tarsal rotation or tarsotomy (or similar techniques), 2) treated the upper eyelid, 3) addressed a patient population in which entropion/trichiasis results from trachoma, and 4) gave a quantitative description of adverse events. We excluded 1) non-English language studies, 2) single case reports, 3) animal studies, and 4) review articles.
A Medline search for case series of "bilamellar tarsal rotation" yielded no case series meeting the above criteria. A Medline search for "tarsotomy" yielded one case series\(^29\) that met the above criteria. Hand searches of the trials located by the first systematic search revealed two case series for bilamellar tarsal rotation\(^{30,31}\) and five for tarsotomy\(^7,29,32-34\) that reported adverse events (table 3). We did not assess internal and external validity for these studies, because no case series could meet the validity criteria. We did look at whether studies clearly defined adverse events, so at least we would understand exactly what the studies meant by the particular adverse events reported in that setting. Our goal was to detect any overall pattern suggesting a difference in adverse events between the two techniques.
III. Results

Randomized trials of surgical techniques

Three randomized trials\textsuperscript{25,27,28} directly compared the success rates of two or more surgical techniques. The bilamellar tarsal rotation’s (BTR) success rate proved superior to all but one technique in the 1990 trial, all techniques in the 1992 trial, and not significantly different than the success rate of transverse tarsotomy and rotation (TTR) in the 2002 trial (table 1a). In addition, the 2002 randomized trial found that BTR had a significantly (\(p=.002\)) higher rate of lid notching and pyogenic granulomas than did TTR (table 3a).

In the first randomized trial in 1990, BTR proved superior to eversion splinting, tarsal advance, and tarsal grooving, but not statistically different than tarsal advance and rotation despite a 25% difference in success rate because of the small numbers of patients involved. Although this trial had small and uneven numbers in its treatment arms because the randomization was not done in blocks, it is methodologically sound. The authors did not report masking of outcome assessment in this study, yet the substantial difference in success rates between techniques is unlikely to result from evaluator bias alone. Also, with some techniques in that study, the type of surgery would have been obvious, making masking impossible.

In the second randomized trial in 1992, the authors assigned the surgical intervention according to the clinical severity of trichiasis, either
minor or major. Patients with minor trichiasis (<5 lashes touching the eyeball) received BTR, electrolysis, or cryoablation. In minor trichiasis, BTR's success rate of 80% was significantly higher than the rate of 29% for electrolysis and 18% for cryoablation, with electrolysis and cryoablation having failure rates 6.1 (95% confidence interval: 2.9-12.8) and 7.5 (3.6-15.4) times greater than that of BTR. In patients with major trichiasis (5 or more lashes touching the eyeball) the authors compared BTR to the technique (tarsal advance and rotation) from the previous trial that was not statistically different than BTR. In this trial, tarsal advance and rotation was about three times as likely to fail during the 9-21 month follow-up period as BTR (Hazard of failure of 3.1, 95% confidence interval: 1.9-5.2). The 1992 trial met all of this review's quality criteria for internal validity, and presents strong evidence that BTR is superior to the other techniques employed in the trial.

The 2002 trial also classified patients as either having minor or major trichiasis and then compared the success rates of BTR to TTR according to this clinical classification. In both minor and major trichiasis, there was no statistically significant difference in success rates between BTR and TTR. Unlike the previous two trials, this trial excluded patients who had previous lid surgery, which may make the results more applicable to populations without exposure to surgical treatment. The shorter follow-up period (3 months) of this study and the lack of masked outcomes assessment are weaknesses, yet overall the results of the study provide
reasonable evidence that the success rates of BTR and TTR are not significantly different at 3 months. Also, masked outcomes assessment of a study comparing BTR and TTR may not be possible as BTR involves an incision through the skin of the upper eyelid and TTR does not. This study also found that BTR resulted in pyogenic granulomas and lid notching more often than TTR did (p= .002), yet did not report the actual number of occurrences of these adverse events, nor criteria for evaluating their presence or severity.

**Randomized trials of surgical providers and location**

Of the other two randomized trials (table 1b), one assessed whether provider type, ophthalmologist versus ophthalmic assistant, affected the success rate of the bilamellar tarsal rotation. This study\(^8\) found no significant difference in BTR success rates between ophthalmologists and Integrated Eye Care Workers (P= .24) This trial was large, masked the evaluators of outcome, and yet did not report its method of randomization. Adequate randomization is one of the more significant criteria for assessing the internal validity of a study because inadequate randomization may allow selection bias to influence the results.

The other trial, which employed TTR, assessed whether location, village or health center, resulted in a higher rate of surgical acceptance.\(^26\) Ophthalmic assistants or ophthalmic nurses performed the operation in either setting, so this study does not help us detect a difference in success rates between ophthalmologists performing TTR and ophthalmic
assistants performing them. Even so, this study contributes pertinent information regarding the implication of surgical programs. It demonstrated a trend towards increased surgical uptake in the community centers (20% improvement, p=.15) and no significant difference in TTR surgical success rates between the village and health center locations (92% and 94%, respectively).

Adverse events associated with bilamellar tarsal rotation and tarsotomy

As the current evidence does not demonstrate whether bilamellar tarsal rotation or transverse tarsotomy and rotation is the most successful, we examined the adverse event rates associated with BTR and TTR in the above randomized trials (table 3a) and in case series (table 3b), to see if one was consistently associated with more adverse events than the other. As stated previously, the 2002 trial comparing BTR and TTR found that BTR resulted in significantly more lid notching and pyogenic granulomas in that study than did TTR (p=.002), but did not report the actual numbers of adverse events. The specific occurrences of lid notching and pyogenic granuloma would be helpful in determining the clinical significance of the differences between BTR and TTR. The 2002 trial also reported that BTR resulted in over corrections in 4 (3.2%) of 124 lids and that TTR resulted in zero.
In the other four randomized trials, the studies did not compare BTR and TTR directly. Therefore, because of differing re-infection rates, cultural practices, environmental conditions, and surgical expertise among different populations in different areas, the adverse event rates reported in these trials can only provide a general overview of this issue. For these reasons, we will consider the adverse event rates of BTR and TTR in these four randomized trials along with the adverse event rates of two case series of BTR and five of TTR.

In these randomized trials and case series the rates of pyogenic granulomas for BTR ranged from 0% of 79 lids in a 2004 case series\textsuperscript{31} to 14% of 1286 lids in a randomized trial also conducted in 2004.\textsuperscript{8} In the randomized trials and case series reporting on TTR, the rates of pyogenic granuloma spanned a similar range: from 0% of 300 lids in a 1974 case series\textsuperscript{29} and 0% of 154 lids in a 1993 case series\textsuperscript{7} to 15% of 34 lids in a 2002 case series\textsuperscript{33}.

Although lid notching was an adverse event associated with BTR in the trial comparing BTR with TTR, it was not directly mentioned in the other studies of BTR. Even so, similar adverse events associated with BTR occurred in a 1992 randomized trial\textsuperscript{29} (lid closure defects in 1.5% of 151 lids) and in a 2004 trial\textsuperscript{8} (6.2% of 1286 lids had minor irregularities at the lid margin). Other studies reported that TTR also is associated with lid notching. A case series in 1993 found that TTR resulted in mild lid
notching (no corneal exposure) in 6.3% of 144 lids and another in 2002 found slight lid notching in 3.7% of 54 lids.\textsuperscript{7,33}

Over corrections associated with BTR occurred in 2 (1.3%) of 151 lids in a 1992 randomized trial, 1 (3.1%) of 32 lids in the 1990 randomized trial, and 2 (6.5%) of 31 lids that later self-corrected in a 1988 case series.\textsuperscript{27,28,30} No studies involving TTR reported over corrections.
IV. Discussion

Findings

This systematic review of five randomized trials found higher success rates for bilamellar tarsal rotation (upper-lid Wies\textsuperscript{35} or Ballen\textsuperscript{36}) and transverse tarsotomy and rotation (marginal rotation procedure by a posterior approach\textsuperscript{32} or posterior tarsotomy\textsuperscript{34} or Ewing\textsuperscript{37}) compared to other corrective surgical techniques for trichiasis. However, evidence is inconclusive regarding superiority of BTR versus TTR. In addition, data on adverse events from the included five randomized trials and the five case series presents a mixed picture of whether one of the techniques is associated with more adverse events than the other. Moreover, the clinical relevance of the two adverse events (pyogenic granuloma and lid notching) associated more frequently with BTR than TTR in the 2002 trial warrants further discussion.

As the performance of this operation in the communities where it is needed is important to its acceptance, the practicality of performing the operation in outpatient, temporary conditions is important. Two of the above randomized trials address this issue and both BTR and TTR appear effective in community settings with non-ophthalmologist surgeons.\textsuperscript{8,26} In addition, both the BTR and TTR are relatively simple to perform with little equipment.
Internal Validity

Even with the relatively few patients in each of the treatment arms of the 1990 randomized trial, the study demonstrated BTR's superior success rates when compared to eversion splinting, tarsal advance (lid split), and tarsal grooving. That is, the differences in success rates between BTR and the other techniques in the study were large enough that they were apparent even with treatment groups of about thirty lids each. The 1992 trial comparing BTR with electrolysis, cryoablation, and tarsal advance and rotation provides good evidence that BTR results in superior success rates than these other methods do. With respect to the results from the 1990 and 1992 randomized trials, no further need exists for research of the other techniques present in those trials, as we may reasonably conclude that BTR is superior. Unless of course, other experts in the field would modify the application of the surgical methods included in those trials, as is the case with a recent case series published in May, 2004. This study reported good results with a combined method of the modified tarsal wedge resection and the eversion splinting-grey line incision. Without a trial of this method including a comparison group, however, it is difficult to make conclusions about its success rate compared with other techniques.

The 2002 randomized trial suggesting equality between BTR and TTR has two weaknesses, a relatively short follow up period of three months, and a lack of masked outcomes assessment. Studies have
reported significant recurrence rates after a period of three months, although such recurrences may result from continued scarring rather than any deficit in surgical technique. Even so, a longer follow-up period would be ideal.

As mentioned previously, performing a masked outcomes assessment of BTR and TTR is difficult because BTR involves an incision through the skin of the upper eyelid and TTR does not. Therefore, masking the evaluators of surgical success would be difficult, as BTR may leave a scar that is visible when the eye is closed. The complete closure of the lid as in sleep is a desired outcome after a lid operation and it would therefore be difficult to avoid seeing a visible scar on the closed lid during the evaluation process.

Each of the randomized trials clearly defined success as no lashes touching the lid either in any position or in the primary position of gaze. These definitions are clearer and more reproducible than certain case series that simply reported failures as those lids that needed repeat surgery. Although the above definitions are clear, they are strict and may count as failures lashes that touch the eye only peripherally. Peripheral lashes brushing against the eyeball would still cause discomfort and peripheral scarring but might not increase the likelihood of blindness resulting from scarring over the pupil.
External Validity

The three randomized trials that directly compared surgical techniques employed either ophthalmologists or second year ophthalmology residents. As non-ophthalmologists may perform many of the operations in the future, studies that employ them to determine the success rates of surgical techniques may have greater applicability than studies that employ ophthalmologists do.

The randomized trial that addressed this issue compared ophthalmologists to integrated eye care workers and found no significant difference in the success rates of BTR between these two. Therefore, the importance of having non-ophthalmologist surgeons participate in trials comparing different techniques may be less critical for future trials. On the other hand, although a trial exists demonstrating BTR to be equivalent when performed by ophthalmic assistants and ophthalmologists, perhaps other techniques do not have equivalent success rates between provider types. Also, training non-ophthalmologist surgeons in different techniques in a single study may help elucidate which technique is the simplest to teach. Although the success rates of TTR between ophthalmologists and ophthalmic assistants has not been directly compared, the randomized trial that conducted TTR in community or health center locations found good and similar success rates between non-ophthalmologist surgeons in both areas.26
The randomized trial\textsuperscript{25} comparing BTR and TTR excluded those who previously had surgery, making its results more applicable to populations that have not yet been exposed to surgery. This is a weakness of this study if most endemic populations have already received surgery, but if the opposite were true, it would be a strength.

All five of the randomized trials occurred in places where trachoma is endemic, an important component to ensure applicability to performing surgery in other trachoma endemic areas. With respect to eliminating trachoma, Melese and coworkers\textsuperscript{39} argue that trials of interventions for trachoma should occur in the hyper-endemic areas, for these areas are where trachoma interventions critically need to work. In the same vein, surgical techniques that prove successful in hyper-endemic areas are more likely to prove successful in other areas as well.

**Surgical Failures**

A key question with respect to surgical success rates is whether failures occur because of progressive scarring resulting from trachoma or because of poor or inadequate surgery.\textsuperscript{40} A recent prospective case-control cohort study\textsuperscript{31} found that active chlamydial infection (as defined by clinical observation) at 6 months after an operation predicted recurrence of trichiasis at 12 months, lending support to the theory that progressive scarring is at least in part a cause of recurrent trichiasis. The diagnosis of active trachoma, however, does not always correlate with chlamydial infection.\textsuperscript{41} Also, chlamydial infections are frequently present with few
clinical signs of disease.\textsuperscript{42,43} Further research might examine whether clinical evidence of disease or laboratory evidence of chlamydia best predicts surgical failures and what we can do to help people in such cases (perhaps alternative antibiotic regimens or particular surgical techniques).

On the other hand, Soares and Cruz\textsuperscript{28} suggest that improper surgical technique may lead to recurrence of trichiasis. In their case series, recurrences of trichiasis after the posterior tarsotony procedure were always lateral or medial to the cornea. They propose that two surgical errors may have caused this segmental trichiasis: 1) the tarsal incision did not involve the entire tarsal plate, or 2) the tarsal incision was not parallel to the lid margin, resulting in uneven lid eversion. Melese and co-workers\textsuperscript{44} also suggest that surgeons may not extend the incision and stitches far enough medially and laterally to prevent recurrences in these areas of the lid margin. Perhaps grading of the surgical technique (length of incision, consistent distance from the lid margin, appropriate placement of stitches) at the time of surgery and recording location of trichiasis recurrence would provide a connection between recurrences of trichiasis and surgical technique. Also, Taylor suggests that the elapsed time between the operation and surgical failure would help elucidate the cause of recurrence.\textsuperscript{40}
Clinical Classification of Trichiasis and Entropion

Another aspect of the trials relating to success rates is the clinical grading of the severity of trichiasis or entropion before surgery. In the 1992 randomized trial, patients with major trichiasis undergoing surgery had a statistically significant improvement in visual acuity after nine months, whereas those with minor trichiasis before surgery did not. The 2004 trial comparing ophthalmologists to integrated eye care workers employed the clinical classifications of Melese and coworkers and found increased recurrence rates associated with patients who had more severe degrees of trichiasis or entropion at baseline (p<.001). Melese and coworkers classification scheme is detailed and their specific clinical criteria may help determine which surgical techniques are best for which conditions and levels of severity.

Certain ophthalmologists proposed that surgeons should choose the surgical technique to match the severity of entropion or trichiasis to achieve good results. Others have suggested that TTR was successful and simple enough to almost always be the procedure of choice for the initial operation. This theory of certain techniques being appropriate for differing severities has never been tested in a randomized trial. Even so, the current techniques have significant failure rates as time progresses and any clinical information, such as Melese and coworker's classification scheme, that would help predict which eyes may need more complicated and successful surgical techniques, would be helpful.
Adverse Events

The only direct evidence that TTR results in fewer adverse events than BTR comes from the 2002 randomized trial comparing the two techniques.\textsuperscript{25} Although the difference was statistically significant (p=0.002), the study did not report the actual numbers of pyogenic granulomas and cases of lid notching. Also, the applicability of these results may depend upon clinical features of the population and the surgical technique. That is, perhaps TTR is better suited for this population or the surgeons are more familiar with it than with BTR. That being said, in that particular setting, TTR resulted in fewer pyogenic granulomas and cases of lid notching than did BTR.

The other randomized trials and case series present a mixed picture of the adverse events associated with the two procedures, ranging from no complications in both procedures, to pyogenic granulomas occurring in over 10% and lid abnormalities in about 6% of the study populations for both BTR and TTR. We cannot assess whether differences in severity of adverse events existed between BTR and TTR cases because these studies did not include a clinical scale for grading the severity of adverse events.

Nasr\textsuperscript{34} reported that pyogenic granulomas occurred with posterior tarsotomies but not anterior tarsotomies, suggesting that suture to conjunctivae contact predisposes eyelids to this problem. If suture to
conjunctivae contact were indeed the cause, then we would expect rates of pyogenic granulomas to be about the same in BTR and TTR as both involve suture to conjunctivae contact. Reacher and coworkers suggested that granuloma formation might be reduced with more absorbable sutures and their routine removal after the seventh postoperative day.

The clinical significance of pyogenic granulomas and lid notching that does not expose the cornea warrants further discussion. Although pyogenic granulomas are easily excised and mild lid notching may not result in corneal damage, these adverse events may decrease surgical acceptance. Surgical acceptance is already low in many communities where trachoma is endemic and pyogenic granulomas requiring corrective procedures and even slight lid deformities may increase the barriers to gaining a community's trust.

One pattern that did emerge from an examination of the randomized trials and case series was that BTR was associated with over corrections, whereas no one reported this adverse event for TTR. Alemayehu and coworkers reported that over corrections were repaired within the first week after the initial operation, yet they did not report the numbers of BTR requiring additional surgery. Perhaps they view over corrections as a failure on behalf of the surgeon rather than a failure of the technique itself. Even so, if BTR has a propensity to over correction, in addition to the time and cost of repeat surgeries, this adverse event might
discourage others from accepting surgery. On the other hand, one case series\textsuperscript{30} found that the two over corrections occurring following BTR were later self-correcting and Soares and Cruz\textsuperscript{32} suggest that slight initial over corrections (with the TTR, at least) may reduce the incidence of recurrence of trichiasis.

**Conclusion**

The five randomized trials reviewed provide evidence that the bilamellar tarsal rotation and the transverse tarsotomy and rotation are among the most effective procedures for correcting trachomatous trichiasis and entropion. Given the positive results of both BTR and TTR, future research should include randomized trials with the power to analyze adverse event rates. Trials should define the adverse events ahead of time and attempt to develop clinically meaningful scales of their severity.

Also, integrated eye care workers should perform the operations after learning one of the above techniques, to simulate the real world implementation of reaching many people with non-ophthalmologist surgeons. The ease with which each technique is learned to achieve a satisfactory success rate would also be an important outcome of future trials. The education of equally experienced non-ophthalmologist surgeons during the trial period would help ensure that some of them are not already more familiar with one technique than the other.
Further use and evaluation of Melese and co-worker's modified grading system for trichiasis and entropion\textsuperscript{44}, or the development of other clinically meaningful grading systems, might help elucidate whether certain procedures work best for certain conditions or levels of severity. Also, classifying where the recurrences occurred on the lid margin (medial, central, lateral) may help elucidate whether imperfect surgical technique contributed to the failure, as discussed above.
References


1a. Randomized Trials of Surgical Techniques

<table>
<thead>
<tr>
<th>Study</th>
<th>Population</th>
<th>Type and # Operations</th>
<th>Provider Type</th>
<th>Follow-up</th>
<th>Success Rate</th>
<th>Statistical Significance</th>
<th>Visual Acuity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adamu et al. 2002 Ethiopia</td>
<td>77.3% female mean age: 40.7 years Excluded patients with former upper lid surgery</td>
<td>BTR (115) Vs. TTR (122)</td>
<td>2nd year ophthalmology residents</td>
<td>3 mo.</td>
<td>Minor: BTR: 86.1% TTR: 95.1% Major: BTR: 86.0% TTR: 84.0%</td>
<td>P=0.686 P=0.286</td>
<td>Trend towards improvement “in all categories” P=.0515</td>
</tr>
<tr>
<td>Reacher et al. 1992 Oman</td>
<td>75.5% female mean age: 54.7 years</td>
<td>Minor: BTR (52) Electro (57) Cryo (57) Major: BTR (98) TAR (101)</td>
<td>Ophthalmologists</td>
<td>9-21 mo.</td>
<td>Minor: BTR: 80% Electro: 29% Cryo: 18% Major: BTR: 77% TAR: 41%</td>
<td>Hazard of Failure** -- 6.1, 2.9-12.8 7.5, 3.6-15.4 -- 3.1, 1.9-5.2</td>
<td>Minor: No significant improvement Major: Improvement of half a line of Snellen in both methods P&lt;.001</td>
</tr>
<tr>
<td>Reacher et al. 1990 Oman</td>
<td>Age and sex not reported Pregnant women excluded</td>
<td>BTR (41) * TAR (24) ES (24) TA (41) TG (35)</td>
<td>Ophthalmologists</td>
<td>7.4 mo. 8.8 mo. 8.7 mo. 7.5 mo. 7.7 mo.</td>
<td>71% 46% 29% 27% 11%</td>
<td>P&gt;.05 P&lt;.01 P&lt;.001</td>
<td>Not addressed</td>
</tr>
</tbody>
</table>

*Blocking procedure not used during randomization, thus the unequal sizes of groups in this study
**Relative Hazard of Failure as compared to the bilamellar tarsal rotation with 95% confidence intervals.

BTR: Bilamellar Tarsal Rotation (on globe)
TTR: Transverse Tarsotomy and Rotation (on globe)
TAR: Tarsal Advance and Rotation
ES: Eversion Splinting
TA: Tarsal Advance (lid split)
TG: Tarsal Grooving

Minor: Minor Trichiasis (<5 lashes mo: months
Major: Major Trichiasis (>5 lashes
Electr: Electrolysis
Cryo: Cryoablation
# Table 1b. Randomized Trials of Provider Type or Location

<table>
<thead>
<tr>
<th>Study</th>
<th>Population</th>
<th>Type and # Operations</th>
<th>Follow-up</th>
<th>Provider Type/Location and Success Rate</th>
<th>Statistical Significance</th>
<th>Visual Acuity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alemayehu et al. 2004 Ethiopia</td>
<td>Excluded patients with prior surgery</td>
<td>BTR 1286 lids</td>
<td>3 mo.</td>
<td>Ophthalmologists: 87.9% Integrated Eye Care Workers: 90.1%</td>
<td>P=0.24</td>
<td>Not addressed</td>
</tr>
<tr>
<td>Bowman et al. 2000 Gambia</td>
<td>77.2% female Subsistence farmers, no access to latrines Only patients with major trichiasis</td>
<td>TTR 158 lids</td>
<td>3 mo.</td>
<td>Village: 92% Health Center: 94% Ophthalmic Nurses &amp; Ophthalmic Assistants performed operations</td>
<td>not statistically significant</td>
<td>Not addressed</td>
</tr>
</tbody>
</table>
### Table 2a. Internal Validity of Randomized Trials of Surgical Techniques

<table>
<thead>
<tr>
<th>Study</th>
<th>Method of Random Allocation</th>
<th>Follow-up rates</th>
<th>Subjects analyzed by original allocation</th>
<th>Other treatments described</th>
<th>Definition of success</th>
<th>Masked outcomes assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adamu et al. 2002</td>
<td>Lottery method</td>
<td>92.6% at 3 mo</td>
<td>Yes</td>
<td>6 weeks tetracycline ointment</td>
<td>No lash or eyeball contact in any position Complete lid closure No under or over-correction of lid margin</td>
<td>Not reported</td>
</tr>
<tr>
<td>Reacher et al. 1992</td>
<td>Sealed envelopes of computer sequences</td>
<td>94% at 9 mo. and/or 21mo.</td>
<td>Yes</td>
<td>6 weeks tetracycline ointment</td>
<td>No lash or eyeball contact in primary position No h/o of epilation or further surgery Complete lid closure No over-correction of lid closure or lid margin No onset of phthisis</td>
<td>The evaluator of outcome did not review records before making the assessment.</td>
</tr>
<tr>
<td>Reacher et al. 1990</td>
<td>Random number tables</td>
<td>93% at mean of 7.9 months</td>
<td>Yes</td>
<td>6 weeks tetracycline ointment</td>
<td>No lash/eye ball contact in primary position. Complete lid closure.</td>
<td>Not reported</td>
</tr>
</tbody>
</table>
### Table 2b. Internal Validity of Randomized Trials of Provider Type or Location With Respect to Surgical Outcomes

<table>
<thead>
<tr>
<th>Study</th>
<th>Method of Random Allocation</th>
<th>Follow-up rates</th>
<th>Subjects analyzed in originally assigned groups</th>
<th>Other treatments</th>
<th>Success definition</th>
<th>Masked outcomes assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alemayehu et al. 2004</td>
<td>Not reported</td>
<td>72.6% (713/982)</td>
<td>Yes</td>
<td>Tetracycline ointment twice daily until tube empty</td>
<td>No lash to eyeball contact in all positions of gaze</td>
<td>Yes</td>
</tr>
<tr>
<td>Bowman et al. 2000</td>
<td>Randomized by geographical clusters, but randomization method not reported</td>
<td>100%</td>
<td>Yes</td>
<td>Not reported</td>
<td>Absence of trichiasis</td>
<td>No</td>
</tr>
</tbody>
</table>
Table 3a: Adverse Events of BTR and TTR in Randomized Trials

<table>
<thead>
<tr>
<th>Study</th>
<th>Type and # Operations</th>
<th>Follow-up</th>
<th>Types of Failures and Adverse Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adamu et al. 2002 Ethiopia</td>
<td>TTR: 132 lids BTR: 124 lids</td>
<td>3 months</td>
<td>“Lid notching and granuloma formation were more significant in BTR than in TTR (p=.002).” BTR resulted in 4 over-corrections while TTR resulted in 0 Lid edema in 5 BTRs and in 3 TTRs BTR resulted in 1 infection and 2 cases of wound bleeding in the 2nd week post-op</td>
</tr>
<tr>
<td>Reacher et al. 1992 Oman</td>
<td>BTR: 151 lids</td>
<td>9 and/or 21 months</td>
<td>2 eyes had 0.5 mm closure defect 2 had ectropion; 2 had over-correction Conjunctival suture granulomas in 19 of 151 lids (12.6%)</td>
</tr>
<tr>
<td>Reacher et al. 1990 Oman</td>
<td>BTR: 32 lids</td>
<td>7.4 months</td>
<td>1 over-correction 2 eyes (6%) had granulomas</td>
</tr>
<tr>
<td>Alemayehu et al. 2004 Ethiopia</td>
<td>BTR: 1286 lids</td>
<td>3 months</td>
<td>100 (14%) of patients had granulomas 44 (6.2%) of patients had minor irregularities at lid margins Over and under-correction mentioned, but not quantified.</td>
</tr>
<tr>
<td>Bowman et al. 2000 Gambia</td>
<td>TTR: 158 patients</td>
<td>3 months</td>
<td>Suture granuloma in 1 patient 2 cases of lid edema 1 mild wound sepsis</td>
</tr>
</tbody>
</table>

BTR: Bilamellar Tarsal Rotation  
TTR: Transverse Tarsotomy and Rotation
Table 3b: Case series and adverse events

<table>
<thead>
<tr>
<th>Study</th>
<th>Type and Provider</th>
<th># Lids or Patients</th>
<th>Success Definition of Follow-up Adverse Events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zhang et al. 2004 Nepal</td>
<td>BTR: Not reported</td>
<td>79 lids</td>
<td>75% No recurrence of trichiasis 12 months</td>
</tr>
<tr>
<td>Babalola 1988 Nigeria</td>
<td>BTR: Ophthalmologists</td>
<td>31 lids</td>
<td>77% No electrolysis or additional operations required &gt; 1 year</td>
</tr>
<tr>
<td>Soares et al. 2004 Brazil</td>
<td>TTR: Non-ophthalmologist physician</td>
<td>73</td>
<td>77% No recurrence of trichiasis 6 months</td>
</tr>
<tr>
<td>Bowman et al. 2002 The Gambia</td>
<td>TTR: Ophthalmic nurses</td>
<td>54 lids</td>
<td>72% No lash to eyeball contact 6 or 12 months</td>
</tr>
<tr>
<td>Bog et al. 1993 Tanzania</td>
<td>TTR: Ophthalmic nurse</td>
<td>144 lids</td>
<td>82.6% No lash to eyeball contact 92% Mean of 25.5 months</td>
</tr>
<tr>
<td>Nasr Saudi Arabia 1989</td>
<td>TTR: Ophthalmologists</td>
<td>500 patients</td>
<td>82% Average of 24 months</td>
</tr>
<tr>
<td>Halasa &amp; Jarudi 1974 Lebanon</td>
<td>TTR: Ophthalmologists</td>
<td>300 lids</td>
<td>97% Additional operations not needed 6 months to 9 years</td>
</tr>
</tbody>
</table>

BTR: Bilamellar Tarsal Rotation
TTR: Transverse Tarsotomy and Rotation