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An assessment of potential factors associated with surgical success and improvement in visual acuity in community-based trichiasis surgery camps in the Busoga region of Eastern Uganda

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Rollins School of Public Health of Emory University
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Abstract

An assessment of potential factors associated with surgical success and improvement in visual acuity in community-based trichiasis surgery camps in the Busoga region of Eastern Uganda

By Krishnaveni Subbiah

Background: Trichiasis surgery is a simple and quick procedure that can be performed by local trained nurses and healthcare professionals in order to treat trichiasis and prevent permanent blindness. Sightsavers Uganda currently supports trichiasis surgery in twelve trachoma hyper-endemic districts throughout the Busoga sub-region of Eastern Uganda.

Purpose: The objective of this study was to examine the potential predictor variables for successful trichiasis surgery and improvement in visual acuity across four districts in this sub-region.

Methods: Data was extracted by retrospective chart review of surgical records of patients who received surgical treatment at the March 2015 trichiasis camps across four districts of this region. Only patients who returned for 10-day follow-up examination after surgery were analyzed. Cross tabulations and percentage proportions were evaluated using Wald X^2 test and Fisher's exact test. Univariate and multivariate associations between potential predictor variables and each of the two outcomes were assessed using logistic regression analysis.

Results: The data showed high TT surgical success of 92.7% and 10-day follow-up of 81.3%, among all operated eyes. Predictors of surgery success were surgery district, the eye operated and the operation type. The multivariate logistic regression model included these three terms, plus two interaction terms of district and eye operated, and district and operation type. Improvement in visual acuity was explained by surgery district, gender and signs of epilation prior to TT surgery, each independently and when take together.

Conclusions: Trichiasis surgery is successful in this endemic area of the Busoga region, however, the proportion percentages of success varies by district. Surgical outcome is not associated with improvement in visual acuity. Improvement in visual acuity after trichiasis surgery is marginal, if at all. The primary purpose of trichiasis surgery is to reduce the burden of lashes rubbing against the cornea in order to prevent irreversible blindness.

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BACKGROUND/LITERATURE REVIEW

Trachoma is caused by infection of the bacterium *Chlamydia trachomatis*, and can be spread by direct contact with contaminated flies, by human contact with eye or nose discharge, or via fomites carrying the infectious agent. Endemic trachoma is typically found in areas of inadequate water supply, lack of sanitation facilities and poor hygiene (3). This neglected tropical disease is the world's leading cause of preventable blindness, with 21 million people infected, and at least 229 million who are at risk and living in endemic areas worldwide (3, 5). Trachoma infection causes scarring of the conjunctiva which then leads to the inward rotation of the eyelid, causing trachomatous trichiasis (TT) where the eyelashes scratch against the cornea. If left untreated, the rubbing of lashes on the eyeball can ultimately leading to irreversible blindness (1-3). Trichiasis can be corrected by eyelid surgery, a procedure that reverses the in-turned lashes.

Trichiasis surgery is a simple and quick procedure that can be performed by local trained nurses and healthcare workers. The two methods of trichiasis surgery recommended by the World Health Organization (WHO) are Trabut, also known as Posterior Lamellar Tarsal Rotation (PLTR), and Bilamellar Tarsal Rotation Procedure (BTRP). The Trabut operation consists of an incision made through the posterior conjunctiva and tarsal plate, whereas in the bilamellar tarsal rotation technique the incision is made through the full thickness of the upper eyelid (Appendix A). In both cases, the eyelid margin is then rotated outward and sutured so that the trichiatic lashes are no longer rubbing against the cornea (6).

In order to effectively treat and prevent blinding trachoma, the WHO, along with numerous partner groups and organizations, has endorsed the implementation of the SAFE strategy. The four components of this approach consist of: (1) surgery, in order to eliminate the in-turned lashes and reduce the risk of blindness resulting from corneal abrasion, (2) antibiotic therapy, to treat communities with active trachoma and minimize the reservoir of infection, (3) facial cleanliness to prevent future infection and (4) environmental improvements, to reduce transmission of disease (3). The surgical component is being implemented by many ministries of health and their partners, both in the governmental and private sector, to deliver surgery as a treatment intervention to areas with limited access and resources (3).

Although the increasing delivery of surgical services to hyper endemic, low-resource locations has drastically reduced the global surgical backlog and incidence of disease, trichiasis can re-occur post-surgery. It is likely that early recurrence (i.e. that occurring within the first six months after surgery) results from poor surgical techniques; late recurrence is more likely due to reinfection and ongoing disease progression. Late recurrence can occur after several years (7-10). Incidence of recurrence varies, but has been shown to increase with time since surgery. A majority of studies have reported the cumulative incidence of recurrence to be 10% at three months, an average of 20% at one year, and up to 60% after three years post-operation (7, 8, 10). A study in Vietnam reported the cumulative incidence of recurrence to be 8.8% at one year after surgery and 15.6% at two years (11). On the other hand, some studies have reported no significant increase in the cumulative incidence of recurrence, such as recurrence of 32% at six months, 40% at twelve months and 41% after four years among post-operated patients (9).

Despite the availability of TT surgical services, many individuals still decline free community-based surgical treatment due to lack of time, fear of surgery, misconstrued notions about the procedure and other personal or religious beliefs. A large percentage of those who decline surgical services are still happy to practice epilation (12). Epilation, the act of plucking one's lashes that are touching the eyeball, is a common practice for self-management of TT. However, self-epilation is associated with a high risk of visual impairment due to poor execution, especially by use of low-quality forceps. Thus, the WHO advises that epilation only be done by a trained health care worker, and only when surgery is not an option. For instance, epilation is a reasonable alternative in areas where there is a shortage of TT surgical services or for individuals who decline TT surgery (12-15).

Although the primary goal of trichiasis surgery is to reverse the in-turned eyelashes rubbing on the cornea, which can lead to permanent blindness, several studies have reported on the effect of trichiasis surgery on visual acuity. A study from Ethiopia concluded significant improvement in visual acuity at six months post trichiasis surgery. 74% of participants were female and 80% had surgery on both eyelids. All participants had some vision impairment, 79% showed signs of epilation and 39% had major trichiasis. Further analyses illustrated severity of trichiasis, and age, both independently associated with worsening visual acuity, and no differences by sex. There was a significant mean improvement in average visual acuity post operatively, with the final model for this improvement containing only baseline trichiasis severity as a significant predictor (16).

A study from Gambia also reported an improvement in visual acuity, between baseline and one year after trichiasis surgery with continual improvement at four years postoperatively (9). On the other hand, a randomized controlled study, also conducted in Gambia, concluded no significant difference in improvement of visual acuity between operated eyes and non-operated eyes (17). Another study, from surgery camps in Ethiopia, also reported no change in visual acuity from baseline to 12-month and 24-month follow-up assessments (14).

Despite these varying conclusions on improvement of visual acuity, trichiasis surgery is reported effective in community-based settings for the primary purpose of treating trichiasis and controlling further spread of disease. A study in Tanzania, in which 84% of participants were female, 69% were over 50 years old and 67% had bilateral trichiasis, not only was recurrence low and not significantly affected by age or sex, but also the percentage proportion of surgical success was much higher than the percentage proportion of surgical failures. Success, defined as zero lashes touching the globe, was evaluated at 6 months post-surgery and was achieved in 83% of participants, showing that in such rural, low-resource and community-based settings, conducting trichiasis surgery can be effective in minimizing disease rates (18). Patients also report satisfaction and improvement in quality of life post operation. A study in Ethiopia reported that over 98% of participants reported improvements from surgery, due to correction of trichiasis, elimination of pain and improved vision. 97% stated that they would undergo surgery again if it were required and 96% would recommend the procedure to others, reflecting effective efforts of the trachoma program in this hyper endemic area (19).

However, despite positive efforts and patient satisfaction from such surgery programs, the worldwide surgery backlog is too extensive in order to reach the WHO's global initiative of eliminating trachoma by 2020. Not only is the caliber of delivery of surgical services not enough, certain areas also report poor surgical outcomes, or high rates of surgery refusals (20). Thus, solely providing treatment services is not enough to clear the backlog. More efforts in surgical outreach, uptake and education are needed to effectively solve this endemic. In addition, implementation of the three other components of the SAFE strategy, especially the "F" and "E" aspects, which fall short in promoting and implementing measures compared to the first two elements, would need to substantially progress as well (3). Positive surgical results and scaling up of TT surgical services are essential, however, success across all four parts of the SAFE strategy are needed for effective and long term trachoma control.

INTRODUCTION

Trachoma remains the leading infectious cause of blindness in the world (5). The final stages of this disease involve inward rotation of the upper eyelid (entropion), caused by scarring of the inner lining (conjunctiva) of the upper eyelid, and trichiasis, the painful scratching of eyelashes against the cornea, which eventually leads to irreversible blindness (6). Trichiasis surgery is a simple and quick procedure that can be performed by local trained nurses and healthcare professionals in order to treat trichiasis and prevent permanent blindness.

The largest global burden of this disease is seen in Africa, particularly in areas of poor access to education, water and sanitation (3). Sightsavers, a UK based international non-governmental development organization, has partnered with several other organizations to fast track the elimination of blinding trachoma in these endemic areas. The Sightsavers Uganda office was established in 2008 and is actively working to lower the prevalence of trichiasis by delivering free surgical treatment throughout various regions of the country.

Sightsavers Uganda currently supports trichiasis surgery in twelve trachoma hyper-endemic districts throughout the Busoga sub-region of Eastern Uganda. Over the years, trained health workers have carried out over 30,000 trachomatous trichiasis (TT) surgeries and continue to perform approximately 800 surgeries per a month (21). However, since these surgeries take place in rural, low-resource settings, the quality of these services, as well as, participant attendance have not been monitored. Thus, there is a need to evaluate surgical success through evidence-based support. This project aims to use the current patient record system developed by Sightsavers, to compare services by district and produce an assessment of potential predictors associated with successful surgery and improvement in visual acuity from TT surgical camps conducted in four hyper endemic districts of the Busoga region (6, Appendix B).

METHODS

Study design and participants

This study involved retrospective chart review of patients receiving trichiasis surgery in the Busoga sub-region of Eastern Uganda. The four districts of interest within this region were the Iganga, Jinja, Kaliro and Mayuge districts, each of which has an established trachoma program overseen by Sightsavers, through funding by the Queen Elizabeth Diamond Jubilee Trust. Each of these districts held several TT surgical camps during the month of March 2015 at community-level health centers. Patients were recruited through media advertisements, campaigns at churches and schools, contact with local chairpersons and tribal leaders, and vehicle broadcasts, prior to the start date of these camps. Each district maintained files of surgical lists, standardized forms generated and distributed by Sightsavers. These data books also served as medical records for all the trichiasis surgeries that were performed, and were obtained from each districts' health office through correspondence with the district health clinic officer and lead ophthalmic clinical officer.

All individuals who attended the camps were screened by one of the participating ophthalmic clinical officers for upper lid Trachomatous Trichiasis, defined as the presence of at least one eyelash rubbing on the eyeball or evidence of eyelash removal (epilation) (1). All ophthalmic clinical officers had completed trainings on trichiasis surgery, practices for trachoma control, and instruction on executing the TT camps, prior to working the surgical camps, as offered under the Sightsavers outreach program. Trichiasis surgery was conducted by an ophthalmic clinical officer after receiving consent from the patient.

Chart Review

The surgical form consisted of three major components, to mimic the patient information recorded during the three parts of the surgical camps: (1) the initial baseline screening, (2) the trichiasis surgery, and (3) the 10-day follow-up examination. The first part recorded demographic and baseline medical information. Participants were asked to provide their age, sex, residency and any useful contact information such as a mobile phone number or name of their village chairperson. The baseline clinical conditions involved measurements from a test for visual acuity, and screening for corneal opacity and severity of trichiasis, in both eyes. Visual acuity had been measured using Tumbling-E charts at a 6 meter distance and corneal opacity was noted if there was white color or clouding over the cornea. For those who were unable to read the chart, visual acuity was tested by counting fingers at a reduced distance, or was graded as hand movements, perception of light or no perception of light. It was noted whether or not there were signs of epilation, in addition to the severity of trichiasis, which was measured by counting the number of lashes touching the eye.

If consent for trichiasis surgery was received, aspects of the surgery were recorded in the second part of the surgery form, including which eye was operated, or both, whether each eye was previously operated, and any signs of epilation and presence of cataract in either eye. Evidence of epilation was identified as the absence of lashes or presence of newly growing or broken lashes. Other surgical variables recorded included the type of operation performed (Trabut or Bilamelar) and if a single 1-g dose of azithromycin was consumed postoperatively. After the TT operation, patients had been instructed to return the next day for a short follow-up during which the operated eye was examined for any immediate post-operative complications. Attendance was recorded on each respective patient's surgical form and counseling on management and prevention of further reinfection had been provided. The individual was then sent home and instructed to return after 10 days, during the next session of the TT camps at the same health center, for a 10-day post-operative examination.

The final part of each patient's surgery form involved clinical information on patient's visual acuity and severity of trichiasis, which were measured during the 10-day follow-up, using the same methods as at baseline. It is important to note that the patient did not always receive the same ophthalmic clinical officer at the baseline assessment, surgery and follow-up exams. Individuals with other ophthalmic pathologies were referred to the regional eye hospital.

Statistical Analysis

Data from the surgical forms were entered into Microsoft Excel 2013 and transferred to SAS 9.4 for analysis. Only TT surgery patients who appeared for the 10-day follow-up assessment were included in the final dataset for analysis. A variable to determine whether a participant received bilateral or unilateral surgery was created at the person-level. Visual acuity was coded as a three level variable, with a score better than 6/18 as normal vision, a score between better than or equal to 6/18 and better than or equal to 6/66 in the low vision range, and any score worse than 6/66 as blindness. Severity of trichiasis was coded as mild trichiasis if at least one lash, but less than or equal to five lashes, were touching the cornea, major trichiasis if six or more lashes were touching the cornea, and "epilated all" if the individual had removed all trichiatic lashes. At 10-day follow-up, individuals who had epilated all their lashes prior to surgery remained in the "epilated all" group, due to no growth of full lashes in ten days, and the severity of trichiasis among the remaining post-operative patients were coded as mild, major, and no trichiasis, if there were zero trichiatic lashes.

The primary outcome was TT surgical success or failure. Post operatively, patients with zero trichiatic lashes at the 10-day follow-up visit were concluded as surgical successes. If at least one lash was touching the cornea then the outcome for that eye was coded as a surgical failure. Patients who had epilated all their lashes, prior to surgery, were excluded from the analysis of this surgical outcome. A secondary outcome, improvement in visual acuity between baseline before surgery, and at 10-day follow-up, was also considered. Raw visual acuity scores, which were recorded as 6/x vision, were converted to logMar units, and an increase by greater than 0.1 logMar units between patient's baseline visual acuity and visual acuity at 10-day follow-up was coded as an improvement in visual acuity. Otherwise change in visual acuity was coded as no change/worsened.

Percentage proportions were calculated with categories of patient demographics and surgery district in order to characterize the study population and provide preliminary analyses at the person level, regarding the characteristics of patients undergoing TT surgery. All further analyses were conducted at the eye level. Individuals who received bilateral trichiasis surgery contributed both eyes to these analyses. Cross tabulations were performed with variables regarding the TT surgical process and visual characteristics at each of the two clinical exams, with surgery district in order to describe differences in percentage distributions between the levels of each variable, as well as, any differences by district. Improvement in visual acuity and surgery success were also cross tabulated by district, as well as, improvement in visual acuity by surgery success. Significant associations in these percentage proportions were evaluated using Wald X^2 test and Fisher's exact test.

Univariate associations between each potential explanatory variable and the primary outcome, surgery success, as well as, the secondary outcome, improvement in visual acuity, were both examined using logistic regression to estimate the odds ratio (OR) and 95% CI. For logistic regression models, age was divided into less than 60 years old and greater than or equal to 60 years old, and range in visual acuity was consolidated to two categories: normal to low vision impairment, and blindness. Models for both outcomes only included individuals from the Iganga and Jinja districts with at least one trichiatic lash at baseline. In addition, for models involving improvement in visual acuity, individuals with normal visual acuity (6/5 or 6/6) or complete blindness (NLP) were excluded.

Variables of statistical significance with each outcome, at the α=0.05 level, were retained in the respective full model for multivariate logistic regression analysis. Model selection for the best predictor model for successful TT surgery, and improvement in visual acuity, was conducted using a three step modeling strategy. Variable interaction was accessed using the hierarchical backward elimination approach, using a 5% significance level for excluding variables from each of the two full models. Then potential confounding and test for precision were considered. The remaining final logistic regression model was also examined for goodness of fit.

RESULTS

Study Participants

During the TT surgical camps, across the four districts of this study, Iganga, Jinja, Kaliro and Mayuge, there were 1,211 patients with trichiasis in at least one eye (Figure 1). Out of these, 1,195 (98.7%) consented to TT surgery with 16 (1.3%) patients refusing surgical treatment. Reasons for refusal are shown in Figure 1. Of those that received surgery, 971 (81.3%) patients returned for the 10-day follow-up, consisting of 96.1% of the operated individuals from Iganga, 58.7% from Jinja, 63.3% from Kaliro and 94.9% from the Mayuge district (Figure 1).

Patient Demographics

The mean age of patients was 66.2 years (SD 10.0; range 13-91). Patients in Iganga were slightly older patients in the other districts (Table 1), and there was slightly more variation in the age of patients in the Kaliro district than in other areas (Table 2, Figure 2). Surgery was more commonly performed on females (63.1%) than males, with a female to male ratio varying from 1.3 to 1.9 in each district. However, the differences in the sex were not statistically significant between districts (Table 1). The percentage of patients that provided any contact information was higher in the Iganga and Mayuge districts, compared to in the Jinja and Kaliro districts. There was no significant difference in the proportion percentages of individuals who were previously operated, or who had bilateral trichiasis surgery, compared to unilateral surgery, between all four districts (Table 1).

TT Surgery

Approximately the same percentage of left eyes were operated, compared to right eyes (Table 2). In the Iganga, Jinja and Kaliro districts, a majority of surgeries were performed using the Trabut technique, compared to the Bilamellar Tarsal Rotation Procedure (BTRP), however, in the Mayuge district more surgeries were performed using the BTRP, compared to Trabut (Table 2). In addition the proportion percentage of post-operative eyes that were examined at the 1-day follow-up was significantly higher in the Iganga (99.8%), Jinja (100.0%) and Kaliro (91.8%) districts, compared to the Mayuge district where only 15.6% of eyes were seen the next day (Table 2).

Clinical Characteristics, by surgery district

At baseline, there were also significant differences in sociodemographic (i.e., age and gender) and disease characteristics (i.e., visual acuity, disease severity and corneal opacification) between the surgical districts (Table 4). There were also associations between older age and corneal opacification, signs of epilation, low or blind vision and major trichiasis. Sex was associated with visual acuity and severity of trichiasis (Table 3). The majority of epilated eyes were in the Kaliro district (65.4%). Within the Iganga and Mayuge districts, a significantly higher proportion of eyes showed major trichiasis, compared to mild trichiasis. In the Iganga, Jinja and Kaliro districts, most surgical eyes were in the low vision range, whereas in the Mayuge district, a larger proportion were in the normal vision range (Table 4).

At the 10-day follow-up exam, there were significant differences in range of visual acuity range and severity of trichiasis between the four districts (Table 5). In the

Iganga and Kaliro districts, the highest proportion of post-operative eyes were in the low vision range (63.3% and 73.1%, respectively), however, in the Jinja and Mayuge districts there were a higher proportion in the normal vision range (52.5% and 64.2%, respectively) compared to in the low vision and blindness ranges (Table 5).

Successful TT surgery

At ten days post-surgery, there was only one failed surgery in the Mayuge district, resulting in a 99.4% prevalence of surgery success, and 100% surgery success in the Kaliro district. Although successful surgery was the norm in the Iganga and Jinja districts, the prevalence of surgery success was significantly lower compared to the Kaliro and Mayuge districts (90.7% and 80.5%, respectively) (Table 7).

Univariate associations with TT surgery success are shown in Table 10. Surgery district, eye operated and operation type were independently associated with success. The odds of success was higher in Iganga compared to the odds of success in the Jinja district. The odds of surgical success in the right eye was significantly higher than the odds of surgical success in the left eye, and the odds of success among eyes operated using the Trabut technique was higher than the odds of success among eyes that had the BTRP. These three variables remained in the final model for predicting successful TT surgery, in addition to two interaction terms, surgery district with eye operated and surgery district with operation type.

Overall the final model was a significantly good fit for this data (Hosmer-Lemeshow Goodness-of-Fit Test: p= 0.9859) (Table 11). The odds of successful surgery among those operated in the right eye with the Bilamellar method, in the Iganga district was significantly higher than the odds of successful surgery among those operated in the left eye, under the Bilamellar procedure in the Jinja district. The odds of successful surgery among those with a left eye, Bilamellar operation in Iganga was also significantly higher than the odds of successful surgery among those who received a left eye, Bilamellar operation in the Jinja district. In addition, the odds of successful surgery among those with a right eye, Trabut operation in Jinja, and the odds among those with a left eye Trabut operation in Jinja, were both significantly higher than the odds of successful surgery among those with a left eye, Bilamellar operation in the Jinja district. The three other contrast estimates also showed higher odds compared to this reference group but the odds ratio was not significant (Table 12).

Improvement in Visual Acuity

At ten days post-surgery, all the post-operative eyes in the Kaliro district demonstrated no improvement in visual acuity, and only 13.0% and 9.3% of eyes, in the Iganga and Mayuge districts respectively, showed improvement (Table 6). In contrast, one-third (33.2%) of surgeries performed in the Jinja district resulted in improved visual acuity (Table 6). Furthermore, improvement in visual acuity was not significantly associated with success or failure of surgery (p=0.9318) (Table 8). Approximately the same percentage proportion of eyes showed improvement in visual acuity and surgical success as improvement in visual acuity and surgical failure (24.1% vs 23.7%, respectively) (Table 8).

Univariate and multivariate associations for improvement in visual acuity between baseline and 10-day follow-up, are shown in Table 9. Surgery district, gender, and signs of epilation at baseline were independently associated with improvement. The odds of improvement in visual acuity was higher in Jinja than the odds of improvement in Iganga. The odds of improvement in visual acuity was higher in males compared to females, and the odds of improvement was higher in non-epilated eyes compared to epilated eyes. These three variables were retained in the final model for predicting improvement in visual acuity. Although only surgery district remained significant at the $\alpha=0.05$ level ($p=0.0587$ for gender, $p=0.0685$ for signs of epilation), the overall model was a good fit (Hosmer-Lemeshow Goodness-of-Fit Test: $p= 0.1131$).

DISCUSSION

Overall, TT surgery is successful in this endemic area of the Busoga region, however, the percentage of successful surgeries is varied by district. Surgical success is independently associated with surgery district, the eye operated and the operation type. When taken together, these three variables, in addition to the interaction between district and eye operated and district and operation type, predict surgical success.

On the other hand, successful surgery is not associated with improvement in visual acuity, and both outcomes involves a different set of predictor variables. Improvement in visual acuity can be explained by surgery district, gender and signs of epilation prior to TT surgery, each independently and when taken together to predict this secondary outcome. However, compared to the final model for successful surgery, the model for improvement in visual acuity was not significant at the $\alpha=0.05$ level and was less of an overall good fit for this data. Hence, surgery success and improvement in visual acuity are two completely different sets of outcomes for TT surgery, with the primary purpose to reduce the burden of lashes rubbing against the cornea in order to prevent irreversible blindness. Although improvement in visual acuity may occur after surgery, it is less likely.

The overall results of the primary outcome of this study are positive for the current trichiasis surgery program under Sightsavers for this endemic region. There is a large sample size, and a high TT surgical success of 92.7% and 10-day follow-up of 81.3%, among all operated eyes. Among patients who received bilateral surgery, the correlation between both eyes is not considered because the outcome of surgery success for one eye is independent of the other eye (Kappa coefficient: 0.0639). Thus, these patients are able to contribute both eyes for the analyses.

There are a few limitations to the design of this study. Data quality varied on the thoroughness of information between surgery record forms. There were missing values, especially regarding range of visual acuity and operation type, and thus these records had to be excluded from any analyses with these variables. Because of minimal record of surgical failure and improvement in visual acuity in the Kaliro and Mayuge districts, information from these districts had to be excluded from the logistic regression models. In addition, only individuals who appeared for both baseline and 10-day follow-up were included. However, an evaluation of potential selection bias, by including all patients who did not return for a 10-day follow-up as having successful surgery, versus as having surgical failure, showed that all the associations of potential predictor variables with surgery outcome, except eye operated, changed slightly in either direction of the original odds ratio but still fell within the 95% confidence intervals. Thus, the selection criteria for inclusion of patients for analysis does not greatly impact the univariate associations with surgical outcome, but would change the final model that is selected, since the variable for eye operated would not be included.

In addition, the reported relationships and model selection for the primary outcome was based on odds ratios between the associations of predictor variables with surgery success. A comparison of risk ratio and odds ratio for each univariate association showed that the odds ratio is inflated 1.2 to 1.9 times compared to the risk ratio when the model is structured for surgical success. For the outcome of surgical failure, the odds ratio is less biased, only 0.86 to 0.99 times the risk ratio. Furthermore, a comparison of estimates of risk ratio versus odds ratio for each contrast statement of the multivariate logistic regression model for surgical success showed that the stronger the association, the more inflated the odds ratio, compared to the risk ratio. An odds ratio closer to the null is a better approximation of the risk ratio, compared to a larger estimate of effect, where the odds ratio tends to be highly overblown compared to the risk ratio. For instance, an adjusted odds ratio of 292.22 is 88.55 times the risk ratio, whereas, an adjusted odds ratio of 1.89 is 1.11 times the risk ratio for that same effect (Table 12). However, despite this bias, the outcome is kept in terms of success due to the methodology from prior literature and the primary research question. Thus, even though the odds ratios and models illustrate the direction of associations of interest, the magnitude of each relationship may not be fully accurate, nor should they be interpreted as a risk ratio, since incidence of disease in the population is unknown.

In the future, routine training sessions and assigning team leaders during each camp could overcome many of these limitations. TT surgeons would receive more practice, and feedback, on surgical technique, counseling and data recording, in order to reduce any inconsistencies and promote the importance of effective data quality and management. Longitudinal studies are also necessary to better evaluate the long-term outcomes of trichiasis surgery in this region. These studies would involve periodically assessing post-surgery patients for 6-month, 1-year, 3-year, or even 5-year follow-ups, and would require a more extensive tracking and recording system to bring patients back to the TT surgical camps these future exams. In order to better capture a representative study sample, health workers can also conduct home visits, particularly in hyper endemic areas, as many individuals, especially severe cases and those of older age who may be living alone, do not attend the TT camps and thus are not picked up by the current system for treatment. Such programs do have higher projected costs and require extensive human resources to ensure efficient monitoring and effective delivery of services to these rural and remote areas. These studies, however, can provide a better indication of the incidence of disease, thus allowing absolute risks to be calculated, eliminating potential for misinterpretation using odds ratios.

In conclusion, the data provides evidence that treatment from trichiasis surgery in the TT surgical camps in the Busoga region of Eastern Uganda, is likely to reduce the burden of trichiatic lashes rubbing against the cornea, which has been known to result in relief from pain and prevent irreversible blindness (1-3). Improvement in visual acuity after surgery is marginal, if at all. Although this study shows trichiasis surgery has high success in this area, treatment services should be expanded and further research is needed, in order to more quickly and effectively minimize the high risk of irreversible blindness due to trachoma in this region.

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Table 1. Characteristics by district of 971 surgery participants.

Characteristic	Iganga (I) *n= 548*	Jinja (J) *n= 125*	Kaliro (K) *n= 186*	Mayuge (M) *n= 112*	(all) p-value	I vs J p-value
Age, mean years (SD)[1]	67.8 (9.0)	65.1 (11.0)	62.5 (10.9)	66.1 (10.4)	0.0001	0.0038
Gender						
Female	361 (65.9)	72 (57.6)	109 (58.6)	71 (63.4)	0.1675	0.0813
Male	187 (34.1)	53 (42.4)	77 (41.4)	41 (36.6)		
Provided village chairperson contact	178 (32.5)	7 (5.6)	33 (17.7)	37 (33.0)	<0.0001	<0.0001
Provided mobile contact[2]	31 (5.7)	0 (0.0)	2 (1.1)	4 (3.6)	0.0011	0.0065
Patient residing in surgery district[2]	545 (99.4)	117 (93.9)	180 (96.8)	112 (100.0)	<0.0001	0.0001
Previously operated	32 (5.8)	9 (7.2)	7 (3.8)	3 (2.7)	0.3016	.5660
TT Surgery performed						
Bilateral	247 (45.1)	56 (44.8)	94 (50.5)	61 (54.5)	0.2135	0.9599
Unilateral	301 (54.9)	69 (55.2)	92 (49.5)	51 (45.5)		

Data are n (%) unless otherwise stated.
p-values calculated by X^2 test unless noted otherwise.
[1] Association was evaluated by ANOVA test, using age as a continuous variable
[2] p-value calculated by Fisher's exact test

Table 2. Characteristics of TT surgical process by district for 1429 post-operative eyes.

Characteristic	**Iganga (I)** *n= 795*	**Jinja (J)** *n= 181*	**Kaliro (K)** *n= 280*	**Mayuge (M)** *n= 173*	**(all)** **p-value**	**I vs J** **p-value**
Eye operated						
Left eye	399 (50.2)	90 (49.7)	148 (52.9)	86 (49.7)	0.8650	0.9101
Right eye	396 (49.8)	91 (50.3)	132 (47.1)	87 (50.3)		
Operation type						
Trabut	701 (88.2)	145 (80.1)	252 (91.6)	68 (40.0)	<0.0001	0.0039
Bilamellar	94 (11.8)	36 (19.9)	23 (8.4)	103 (60.2)		
Missing	*0*	*0*	*5*	*2*		
Received azithromycin	795 (100.0)	179 (100.0)	136 (73.5)	151 (100.0)	<0.0001	-
Missing	*0*	*0*	*95*	*22*		
Completed 1-day followup	793 (99.8)	181 (100.0)	257 (91.8)	27 (15.6)	<0.0001	1.0000[1]

Data are n (%).
p-values calculated by X^2 test unless noted otherwise.
[1] p-value calculated by Fisher's exact test

Table 3. Baseline clinical characteristics, by age and by sex, for 1429 post-operative eyes.

Characteristic	**Age**		p-value	**Sex**		p-value
	< 60 years	≥ 60 years		Female	Male	
Corneal opacity, yes	4 (1.5)	56 (4.8)	0.0170	43 (4.7)	17 (3.3)	0.1925
Cataract, yes	6 (2.3)	45 (3.9)	0.2169	33 (3.6)	18 (3.5)	0.8851
Signs of epilation, yes	79 (30.2)	256 (21.9)	0.0046	219 (24.0)	116 (22.4)	0.4802
Range of visual acuity						
Normal Vision (better than 6/18)	100 (47.9)	197 (20.3)	<0.0001	208 (27.6)	89 (20.9)	0.0232
Low Vision (6/18 to 6/66)	101 (48.3)	654 (67.4)		462 (61.3)	293 (68.9)	
Blind (worse than 6/66)	8 (3.8)	119 (12.3)		84 (11.1)	43 (10.1)	
Missing	*53*	*197*		*157*	*93*	
Severity of trichiasis						
Mild (1-5 lashes)	103 (50.2)	363 (35.5)	<0.0001	314 (40.2)	152 (34.1)	0.0335
Major (> 5 lashes)	102 (49.8)	659 (64.5)		467 (59.8)	294 (65.9)	
Epilated all (0 lashes)	*57*	*145*		*130*	*72*	

Data are n (%).
p-values calculated by X^2.

Table 4. Baseline clinical characteristics by district for 1429 post-operative eyes.

Characteristic	**Iganga (I)** *n= 795*	**Jinja (J)** *n= 181*	**Kaliro (K)** *n= 280*	**Mayuge (M)** *n= 173*	**(all) p-value**	**I vs J p-value**
Corneal opacity, yes	52 (6.5)	4 (2.2)	0 (0.0)	4 (2.3)	<0.0001	0.0237
Cataract, yes	17 (2.1)	11 (6.1)	17 (6.1)	6 (3.5)	0.0043	0.0042
Signs of epilation, yes	112 (14.1)	18 (9.9)	183 (65.4)	22 (12.7)	<0.0001	0.1387
Range of visual acuity						
Normal Vision (better than 6/18)	136 (18.7)	41 (22.7)	29 (24.4)	91 (60.3)	<0.0001	0.0039
Low Vision (6/18 to 6/66)	480 (65.9)	129 (71.3)	87 (73.1)	59 (39.1)		
Blind (worse than 6/66)	112 (15.4)	11 (6.1)	3 (2.5)	1 (0.7)		
Missing	*67*	*0*	*161*	*22*		
Severity of trichiasis						
Mild (1-5 lashes)	252 (34.2)	86 (49.4)	66 (43.4)	62 (38.0)	<0.0001	0.0002
Major (> 5 lashes)	486 (65.9)	88 (50.6)	86 (56.6)	101 (62.0)		
Epilated all (0 lashes)	*57*	*7*	*128*	*10*		

Data are n (%).
p-values calculated by X^2.

Table 5. Clinical characteristics at 10-day follow-up, by district, for 1429 post-operative eyes.

Characteristic	**Iganga (I)** *n= 795*	**Jinja (J)** *n= 181*	**Kaliro (K)** *n= 280*	**Mayuge (M)** *n= 173*	**(all) p-value**	**I vs J p-value**
Range of visual acuity						
Normal Vision (better than 6/18)	166 (22.8)	95 (52.5)	29 (24.4)	97 (64.2)	<0.0001	<0.0001
Low Vision (6/18 to 6/66)	461 (63.3)	80 (44.2)	87 (73.1)	53 (35.1)		
Blind (worse than 6/66)	101 (13.9)	6 (3.3)	3 (2.5)	1 (0.7)		
Missing	*67*	*0*	*161*	*22*		
Severity of trichiasis						
No trichiasis	669 (90.7)	140 (80.5)	152 (100.0)	162 (99.4)	<0.0001	0.0003
Mild (1-5 lashes)	15 (2.0)	10 (5.8)	0 (0.0)	0 (0.0)		
Major (>5 lashes)	54 (7.3)	24 (13.8)	0 (0.0)	1 (0.6)		
Epilated all (0 lashes)	*57*	*7*	*128*	*10*		

Data are n (%).
p-values calculated by X^2.

Table 6. Improvement in visual acuity by greater than 1 line (> 0.1 logMAR unit) between baseline and 10-day follow-up, by district, for 1429 post-operative eyes.

Characteristic	Iganga (I) *n= 795*	Jinja (J) *n= 181*	Kaliro (K) *n= 280*	Mayuge (M) *n= 173*	(all) p-value	I vs J p-value
Change in range of visual acuity, baseline to follow-up[1]						
Improved	95 (13.1)	119 (65.8)	0 (0.0)	14 (9.3)	<0.0001	<0.0001
No change/ worsened	633 (87.0)	62 (34.3)	119 (100.0)	137 (90.7)		
Missing	*67*	*0*	*161*	*22*		

Data are n (%).
p-values calculated by X^2.
[1]Excludes 72 eyes with baseline visual acuity at normal (6/5 or 6/6) or total blindness (NLP).

Table 7. TT surgical success and failure by district, for 1227 post-operative eyes.

Outcome	Iganga (I) *n= 738*	Jinja (J) *n= 174*	Kaliro (K) *n= 152*	Mayuge (M) *n= 163*	(all) p-value	I vs J p-value
Success[1]	669 (90.7)	140 (80.5)	152 (100.0)	162 (99.4)	<0.0001	0.0003
Failure	69 (9.4)	34 (19.5)	0 (0.0)	1 (0.6)		

Data are n (%).
p-values calculated by X^2.
[1] Excludes eyes with all lashes epilated before and after surgery: 57 eyes in Iganga, 7 eyes in Jinja, 128 eyes in Kaliro and 10 eyes in Mayuge.

Table 8. Improvement in visual acuity by greater than 1 line (> 0.1 logMAR unit) between baseline and 10-day follow-up, by TT surgical success and failure, for 912 post-operative eyes in Iganga and Jinja districts.

Characteristic	Successful Surgery[2]	Failed Surgery	p-value
Change in range of visual acuity, baseline to follow-up			
Improved	182 (24.1)	23 (23.7)	0.9318
No change/worsened	573 (75.9)	74 (76.3)	
Missing	*54*	*6*	

Data are n (%).
p-values calculated by X^2.
[1]Excludes 27 eyes with baseline visual acuity at normal (6/5 or 6/6) or total blindness (NLP).
[2]Excludes eyes with all lashes epilated before and after surgery: 57 eyes in Iganga, 7 eyes in Jinja, 128 eyes in Kaliro and 10 eyes in Mayuge.

Table 9. Univariable and multivariable associations for improvement in visual acuity by greater than 1 line (> 0.1 logMAR unit) at 10-day follow-up, for post-operative eyes with at least one trichiatic lash prior to TT surgery in the Iganga and Jinja districts[12] (N=852).

Variable	OR	95% CI	p-value
Univariable analysis			
Surgery district, *Iganga*	0.08	(0.05, 0.11)	<.0001
Age, $\geq$ *60 years*	0.70	(0.46, 1.08)	0.1032
Gender, *female*	0.67	(0.48, 0.92)	0.0134
TT surgery, *bilateral*	0.77	(0.56, 1.06)	0.1111
Eye operated, *right eye*	0.97	(0.70, 1.32)	0.8249
Operation type, *Trabut*	0.75	(0.47, 1.19)	0.2171
Epilating, *yes*	0.49	(0.24 1.00)	0.0499
Corneal opacity, *yes*	0.54	(0.25, 1.16)	0.1119
Cataract, *yes*	1.87	(0.80, 4.33)	0.1464
Baseline severity of trichiasis, *major*	1.08	(0.78, 1.49)	0.6645
Multivariable logistic regression			
Surgery District, *Iganga*	0.07	(0.05, 0.11)	<.0001
Gender, *female*	0.72	(0.47, 1.01)	0.0587
Epilating, *yes*	0.45	(0.20, 1.06)	0.0685

p-values calculated by Wald X^2.
[1]Excludes 31 eyes with baseline visual acuity at normal (6/5 or 6/6) or complete blindness (NLP).
[2]Excludes 60 eyes with missing values for range of visual acuity at baseline or follow-up.

Table 10. Univariable associations with successful TT surgery, for post-operative eyes with at least one trichiatic lash prior to TT surgery, in the Iganga and Jinja districts (N=912).

Variable	OR	95% CI	p-value
Univariable analysis			
Surgery district, *Iganga*	2.36	(1.50, 3.69)	0.0002
Age, $\geq$ *60 years*	1.24	(0.71, 2.17)	0.4442
Gender, *female*	1.37	(0.90, 2.08)	0.1405
TT surgery, *bilateral*	1.38	(0.91, 2.09)	0.1266
Eye operated, *right eye*	4.56	(2.77, 7.52)	<0.0001
Operation type, *Trabut*	1.72	(1.02, 2.89)	0.0421
Corneal opacity, *yes*	3.54	(0.85, 14.75)	0.0825
Baseline range of visual acuity, *normal/low vision*	1.39	(0.78, 2.48)	0.2647
Baseline severity of trichiasis, *major*	1.14	(0.75, 1.73)	0.5405

p-values calculated by Wald X^2.

Table 11. Regression coefficients table for multivariable logistic regression model predicting successful TT surgery, for post-operative eyes with at least one trichiatic lash prior to TT surgery, in the Iganga and Jinja districts (N=912).

Parameters	β	95% CI for β	p-value
Intercept	-0.44	(-1.29, 0.41)	0.3066
Surgery district	3.15	(1.71, 4.59)	<0.0001
Eye operated	0.64	(-0.22, 1.49)	0.1426
Operation type	2.21	(1.34, 3.09)	<0.0001
Surgery district x eye operated[1]	1.89	(0.68, 3.09)	0.0022
Surgery district x operation type[2]	-3.44	(-4.92, 1.96)	<0.0001

[1]Interaction term including surgery district and eye operated.
[2]Interaction term including surgery district and operation type.

Table 12. Adjusted odds ratios for each level of effect, using the multivariable logistic regression model[1] for successful TT surgery, for post-operative eyes with at least one trichiatic lash prior to TT surgery, in the Iganga and Jinja districts (N=912).

	Iganga		Jinja	
Variables assigned	**OR**	**95% CI**	**OR**	**95% CI**
Trabut, right-eye operation	85.92	(0.26, 30170.95)	17.39	(3.11, 9.87)
Bilamellar, right-eye operation	293.20	(8.93, 9725.77)	1.91	(0.81, 4.45)
Trabut, left-eye operation	6.86	(0.15, 307.21)	9.17	(3.89, 22.00)
Bilamellar, left-eye operation	23.42	(5.59, 99.03)	1.0	ref.

[1]Logistic regression model includes five terms: surgery district, eye operated, operation type, interaction term for surgery district and eye operated, and interaction term for surgery district and operation type.

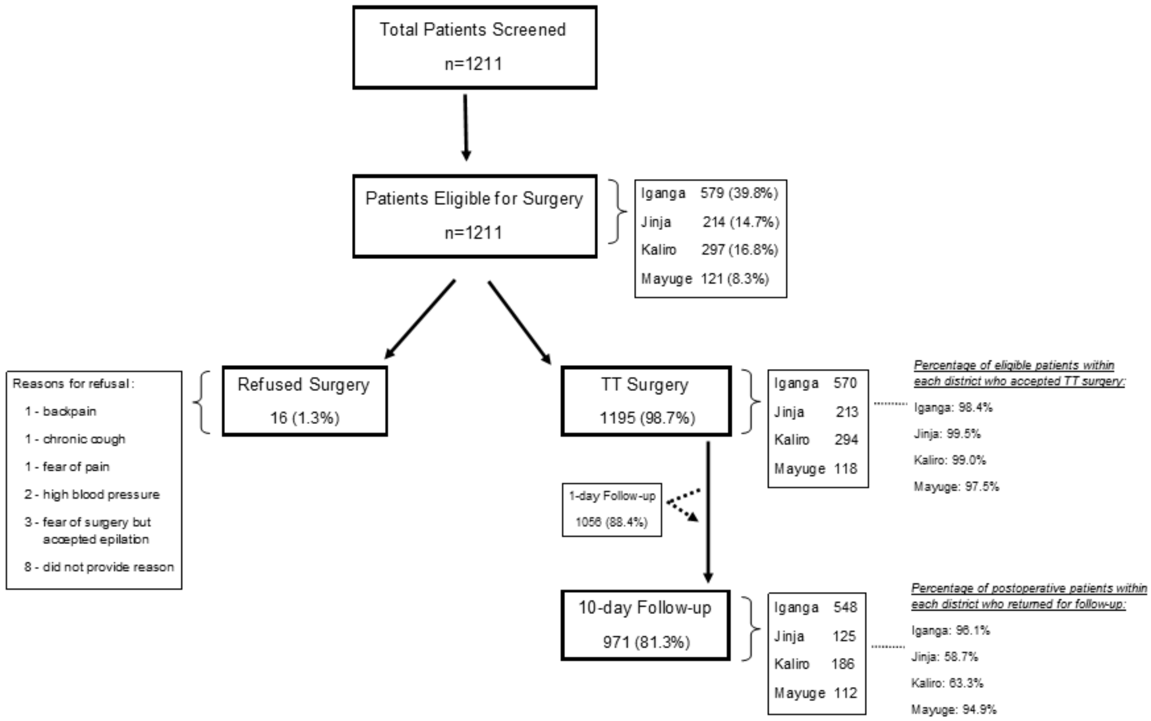


Figure 1: Study patient flow diagram.

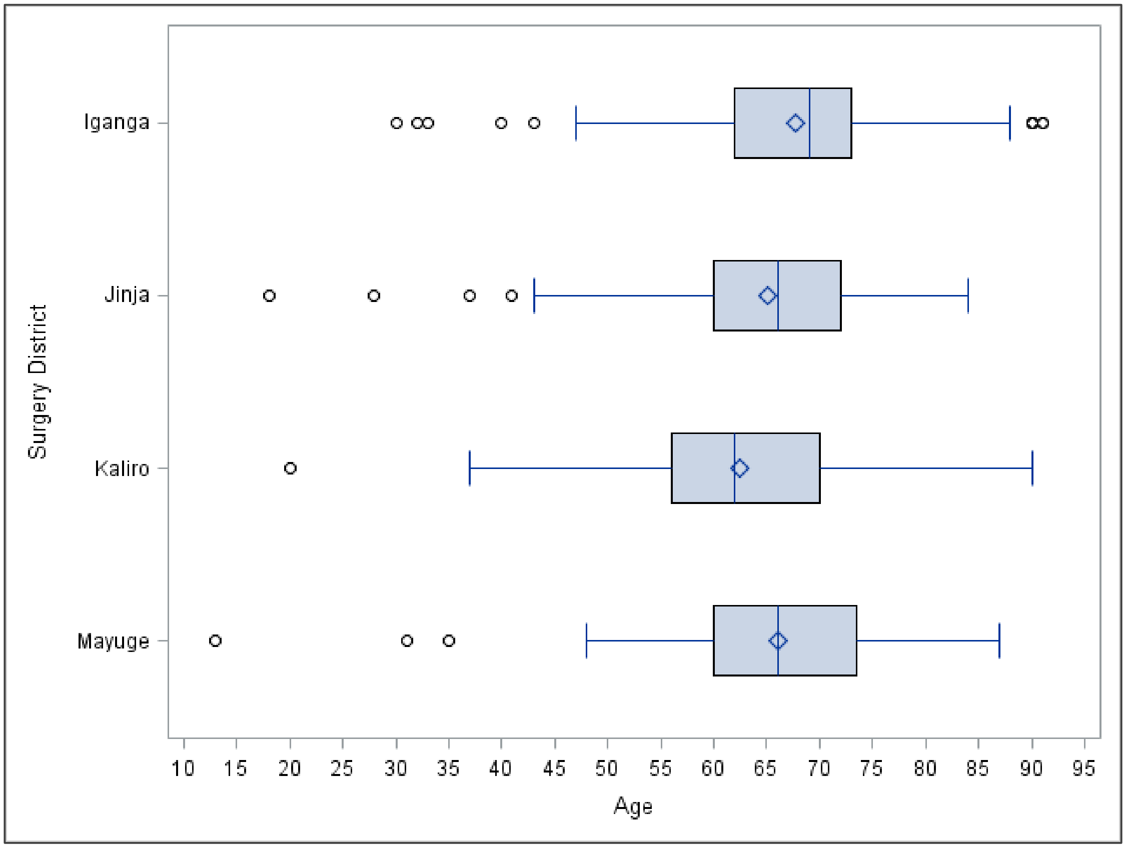
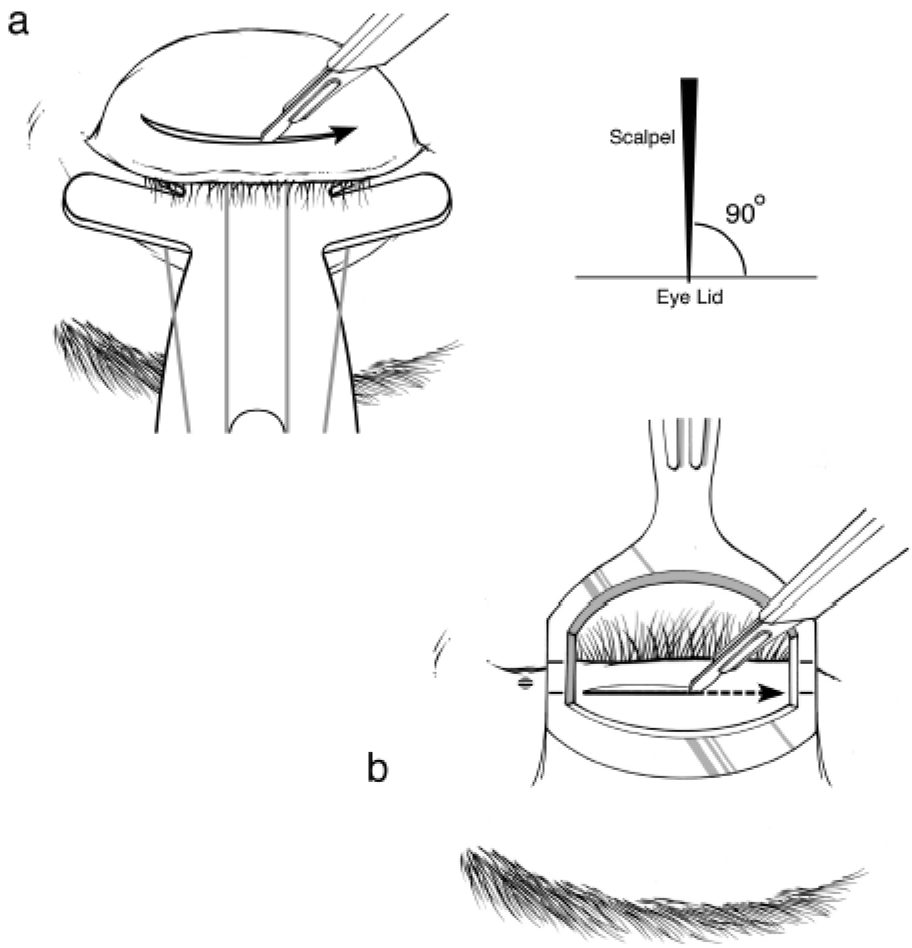


Figure 2. Distribution of age by surgery district.

Appendix A: Incision made on operated eye during (a)Trabut operation with tarsal plate and (b)Bilamellar (BLTR) procedure with Waddell clamp. *source: (6)*



Appendix B: District map of Uganda with the four districts of study interest boxed in yellow: (1) Iganga, (2) Jinja, (3) Kaliro, (4) Mayuge. *source: (22)*