Original Article

Outcomes of chronic macular hole surgical repair

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Purpose: To report visual and anatomic outcomes of chronic macular hole surgery, with analysis of pre-operative OCT-based hole size and post-operative closure type. **Settings and Design:** An IRB-approved, retrospective case series of 26 eyes of 24 patients who underwent surgery for stage 3 or 4 idiopathic chronic macular holes at a tertiary care referral center. **Statistical Analysis:** Student's *t*-test. **Results:** Nineteen of 26 eyes (73%) had visual improvement after surgery on most recent exam. Twenty-one of 26 eyes (81%) achieved anatomic closure; 16 of 26 eyes (62%) achieved type 1, and five of 26 eyes (19%) achieved type 2 closure. Post-operative LogMAR VA for type 1 closure holes (0.49) was significantly greater than for type 2 closure and open holes (1.26, $P < 0.003$ and 1.10, $P < 0.005$, respectively), despite similar pre-operative VA ($P = 0.51$ and 0.68, respectively). Mean pre-operative hole diameter for eyes with type 1 closure, type 2 closure, and holes that remained open were 554, 929, and 1205 microns, respectively. Mean pre-operative hole diameter was significantly larger in eyes that remained open as compared to eyes with type 1 closure ($P = 0.015$). **Conclusion:** Vitrectomy to repair chronic macular holes can improve vision and achieve long-term closure. Holes of greater than 3.4 years duration were associated with a greater incidence of remaining open and type 2 closure. Larger holes (mean diameter of 1205 microns) were more likely to remain open after repair.

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Macular holes, first classified by Gass and Johnson, who described stages of idiopathic holes and precursor lesions, may be repaired with pars plana vitrectomy (PPV), membrane peeling, and gas-fluid exchange, which can achieve anatomic and visual improvement.[1-4] However, most studies have focused on macular holes of less than six months duration, whereas anatomical success with surgery has ranged from 33-85% for chronic macular holes (greater than one year duration).[4-11] Some authors have cautioned against surgical intervention with chronic macular holes due to poor visual prognosis, while others reported visual improvement, defined as halving of the visual angle (corresponding to a two line gain on a standard Snellen chart) in up to 70% of patients.[6,8,11] In this consecutive case series, we report the visual and anatomical outcomes following microincisional PPV, triamcinolone-assisted internal limiting membrane peeling, and gas-fluid exchange for chronic macular holes of greater than one year duration. In addition, mean pre- and post-operative macular hole diameter values were analyzed to determine correlation with final anatomic and visual outcomes.

Patients and Methods

Institutional Review Board approval was obtained from our university for this study. All patients from a single surgeon who underwent surgery for chronic macular holes between August 2006 and October 2008 were reviewed. Twenty-six eyes of 24 patients with stage 3 or 4 chronic idiopathic macular holes of greater than one year duration were included. The duration of the macular hole was determined from when the patient first noticed significant visual loss and as documented on any available previous ophthalmologic examination reports. Mean duration of macular holes was 4.75 years (type 1 closure holes having been present for a mean of 3.4 years and type 2 closure holes being present for a mean of 9 years). The length of time was due to late presentation by patients and/or delayed referral to the Retina Service. Prior to surgery, all patients underwent a complete ophthalmic examination including best corrected visual acuity, slit lamp examination, and dilated funduscopic examination, fundus photography, and optical coherence topography (OCT). In all eyes, the surgical technique consisted of microincisional (25-gauge) pars plana vitrectomy, triamcinolone acetonide (either Kenalog-40, Bristol-Myers-Squibb, Peapack, NJ, or Triesence, Alcon Laboratories, Fort Worth, TX)-assisted internal limiting membrane peeling using 25-gauge membrane peeling forceps (Synergetics, O'Fallon, MO), and gas-fluid exchange using 14% C3F8 (perfluoropropane, Alcon Laboratories, Fort Worth, TX). ILM was peeled using standard pinch-and-peel techniques with an ILM peel of at least 1 disc area around the macular hole as has been described.[12] Instructions for one week post-operative strict face down positioning were given to all patients. Follow-up examinations were conducted at one day, one week, six weeks, and three months for all patients. Longer follow-up information for any patients was also collected if it was available.

Visual improvement was defined as an increase of best corrected visual acuity (VA) by two or more lines on a Snellen VA chart (equivalent to an increase of 0.2 logMAR). Anatomical success was defined as flattening of the edges of the macular hole as well as resolution of any fluid cuff around the hole as determined by both clinical examination and OCT. After

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three months post-operative follow-up, macular holes were categorized as either open or, if closed, as type 1 or type 2 closure, as previously described.[13,14] Briefly, type 1 closure was defined as complete anatomic closure, whereas type 2 closure was defined as closure with persistence of a central neurosensory tissue defect. Snellen VA was converted to logarithm of the minimum angle of resolution (logMAR) VA for analysis.

Differences in VA before and after surgery were then compared using a Student's *t*-test. Pre-operative OCTs were reviewed; 24 eyes were imaged on Stratus or Cirrus OCT (Zeiss) OCT. Calipers in the program were used to analyze superior to inferior hole diameter and nasal to temporal hole diameter. The largest hole diameter in each of these two dimensions was recorded for each eye, and an average was taken as the average hole size. The thickness data obtained from Stratus OCTs were converted to Cirrus measurements using the formula that has been proposed.[15] Differences in macular hole diameter between eyes with type 1 and type 2 closure and eyes in which holes remained open were compared using a Student's *t*-test.

Results

The patient demographics, surgical details, and VA data are listed in Tables 1 and 2. The mean age of patients was 69 years with a range of 53 to 86 years. Fifteen (62.5%) were female and nine (37.5%) patients were male. The duration of the macular hole ranged from 1 to 20 years, with a mean of 4.75 years. There were no post-operative complications that required medical or surgical intervention. Mean post-operative follow-up was 24 months (median 24, range 12-45 months). Mean pre-operative logMAR VA was 1.12 (20/264) with a range of 0.30-3.0 (20/40 to 20/20,000). Mean post-operative logMAR VA was 0.76 (20/115) with range of 0.18-1.7 (20/30 to 20/1,000, $P < 0.005$). Nineteen of 26 eyes (73%) eyes had improvement of VA on most recent exam. Twenty-one of 26 eyes (81%) achieved anatomic closure on both clinical exam and OCT. Sixteen out of 26 eyes (62%) achieved type 1 closure. Five out of 26 eyes (19%) achieved type 2 closure.

Fig. 1 shows examples of type 1 and type 2 closure with OCT. Eyes with closed holes had significantly better mean post-operative VA than eyes without closure [Table 2]. LogMAR VA was 0.67 (20/93) for closed compared to 1.10 (20/252) for open macular holes, respectively (P = 0.005), despite similar pre-operative visual acuities of 1.10 (20/252) and 1.15 (20/282), respectively (P = 0.85). Post-operative VA for type 1 closure holes (0.49) was significantly greater than for type 2 closure and open holes (1.26, $P < 0.003$ and 1.10, $P < 0.005$, respectively), despite similar pre-operative VA (P = 0.51 and 0.68, respectively). Pre- and post-operative VA was not statistically different for type 2 closure and open holes (P = 0.95 and 0.77, respectively). Post-operative VA was not statistically significant between type 2 closure and open holes (P = 0.40).

As shown in Tables 1 and 3, eyes with open or type 2 closure had longer mean duration of macular hole prior to surgery (5.3 and 9.0 years, respectively) compared to those with type 1 closure (3.4 years); but, only the difference between type 1 closure and open holes was statistically significant (P = 0.019). There were five chronic macular holes (24%) that remained open. During the follow-up period, five of 16 eyes (31%) that were phakic underwent cataract extraction with intraocular lens implant an average of 9.7 months after surgical repair.

Mean pre-operative macular hole diameter for eyes with type 1 closure, type 2 closure, and holes that remained open were 554, 929, 1205 microns, respectively [Table 1]. Mean pre-operative hole diameter was significantly larger in eyes that remained open as compared to eyes with type 1 closure [P = 0.015, Table 3]. While on average, hole diameter was larger in eyes with type 2 compared to type 1 closure, the difference was not statistically significant (P = 0.13). Although, on average, hole diameter was larger in eyes with holes that remained open compared to eyes with type 2 closure, the difference was not statistically significant (P = 0.32). On average, patients with type 2 closure tended to be older than those whose chronic macular holes remained open (P = 0.025).

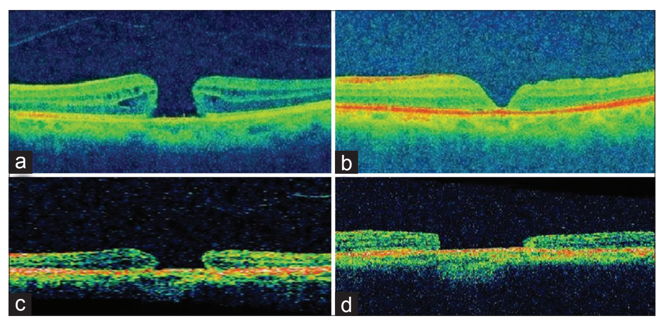

Figure 1: Examples of full thickness macular holes visualized with optical coherence tomography, demonstrating pre-operative (a, c) and post-operative (b, d) result at most recent exam for cases of type 1 (a, b) and type 2 (c, d) closure. Type 1 closure demonstrates relative restoration of the outer retina compared with persistence of a central neurosensory retinal defect observed with type 2 closure

Table 1: Characteristics of study population

Characteristic	All (*N*=26 eyes)	Open (*N*=5 eyes)	Type 1 closure (*N*=16 eyes)	Type 2 closure (*N*=5 eyes)
Age (years)				
Mean (median, range)	69 (69, 53-86)	63 (64, 55-72)	68 (69, 53-86)	76 (77, 64-83)
Hole duration (mos)				
Mean (median, range)	57 (30, 12-240)	64 (24, 12-240)	40 (24, 12-120)	108 (120, 36-132)
Average hole diameter (microns)				
Mean (median, range)	751 (624, 293-1609)	1205 (1360, 723-1609)	554 (555, 293-785)	929 (1061, 447-1465)
Follow-up (mos)				
Mean (median, range)	24 (24, 12-45)	33 (31, 24-45)	21 (20, 12-41)	23 (17, 12-36)

Table 2: Chronic macular hole closure type and visual acuity

Visual acuity (LogMAR)	All (*N*=26 eyes)	Open (*N*=5 eyes)	Type 1 closure (*N*=16 eyes)	Type 2 closure (*N*=5 eyes)
Pre-operative				
Mean (median, range)	1.12 (1, 0.30-3)	1.15 (1, 0.88-1.70)	1.06 (0.94, 0.54-3)	1.28 (1.70, 0.30-1.70)
Post-operative (final)				
Mean (median, range)	0.76 (0.65, 0.18-1.70)	1.10 (1, 0.88-1.30)	0.49 (0.48, 0.18-1.18)	1.26 (1.30, 0.70-1.70)

Table 3: Comparison of closure groups based on hole size, duration, and patient age

Criteria and groups compared	*P* value
Hole size	
Type 1 closure compared to type 2 closure	0.13
Type 1 closure compared to open*	0.019
Type 2 closure compared to open	0.32
Hole duration	
Type 1 closure compared to type 2 closure*	0.015
Type 1 closure compared to open	0.62
Type 2 closure compared to open	0.39
Patient age	
Type 1 closure compared to type 2 closure	0.088
Type 1 closure compared to open	0.21
Type 2 closure compared to open*	0.025

*Statistically significant difference

Discussion

Acute macular hole surgical repair is a well accepted practice among vitreoretinal surgeons for stage 2, 3, and 4 macular holes due to high likelihood of successful closure and a beneficial visual outcome. In contrast, several studies caution against surgical intervention for chronic macular holes, which are greater than one year's duration due to limited visual gain or anatomic success.[4,6-8] A prior study noted a closure rate of 82%, with 70% of eyes demonstrating halving of the visual angle for chronic holes.[11] In our series, 81% of patients had successful anatomic closure and 73% improving visual acuity. Stec *et al*. reported failure in seven of 23 eyes initially operated without ILM peeling, with success on reoperation in six of seven of those eyes with ILM peeling. In contrast, all eyes in our series underwent ILM peeling initially, as it has been shown to improve anatomic success rates.[11,16] A recent study reported 100% chronic macular hole closure rate with combined ILM peeling and autologous platelets.[17] Another study reported 100% macular hole closure with ILM peeling and no face down positioning.[12] Our study is the first to determine OCT-based chronic macular hole size parameters and analyze closure type to help better guide the decision to repair chronic macular holes.

Long-term visual outcomes in cases of macular hole closure with a persistent foveal tissue defect have been shown to be consistently worse than in cases with complete approximation of tissue.[14,18] This is also supported by our data; in our series, 21 of 26 eyes (81%) achieved anatomic closure, with five of 21 of these eyes (24%) achieving type 2 closure. Of the five patients with type 2 closure, four had macular holes of greater than ten years duration and the remaining patient had a macular hole for three years prior to surgery. The pre-operative visual acuity was not statistically different between the type 1 closure, type 2 closure, and open groups. Post-operative visual acuity was statistically significantly greater in patients with type 1 closure than those whose holes remained open.

Of those patients in our series with limited visual improvement, the macular hole either remained open or closed with type 2 closure. As might be expected, those eyes that had holes which remained open had no significant change in visual acuity. However, all eyes showed a trend toward improved visual acuity after surgery. Of note, type 2 closure with flattening at the edge of the hole is considered a successful endpoint in macular hole surgery in several reports.[14,18] Some regard this anatomical variant as successful since it showed a reduction in the hole's diameter and volume of fluid in the cuff around the hole and improvement of post-operative VA in their patient series.[19] It has been postulated that there is neural tissue degeneration at the fovea in chronic macular holes that prevents glial bridging and plugging of the hole, resulting in chronic damage of outer retinal structures over time.[14]

Of the five cases of macular holes that remained open, one patient had the longest duration of macular hole (20 years). The remaining patients had uncomplicated post-operative courses. Despite this, the rate of successful hole closure in this series (81%) is favorable in comparison with other published case series reports on chronic macular hole repair, which range from 62.7- 83%.[10,11]

This is the first case series in the literature to analyze OCT-based pre-operative size of chronic macular holes in relation to hole closure. Attempts were made to convert the few Stratus OCT data points to equivalent Cirrus measurements using the formula mentioned above; nonetheless, this is a limitation of the study. While the sample size is limited, results do indicate that surgery on larger holes (with average diameter larger than 1200 microns) may have a higher rate of anatomic failure (with the hole remaining open after surgery). Our data suggest that between type 1 and type 2 closure, the duration of the hole was a distinguishing factor [Table 3] with type 1 closure holes having been present for a mean of 3.4 years and type 2 closure holes being present for a mean of 9 years. Between type 1 closure and holes that remained open, the pre-operative hole size mattered (554 vs. 1205 microns, respectively). The trend toward older patients (mean 76 years) having type 2 closure compared to younger patients' (mean age 63 years) holes remaining open requires further study. Further study can also be done on any difference between stage 3 and stage 4 chronic macular hole closure.

This case series is the first to analyze OCT-based pre-operative size of chronic macular holes in relation to hole closure achieved using microincisional vitrectomy. This study demonstrates some visual improvement in most patients undergoing repair of chronic macular holes. Our study contributes OCT-based hole size parameters to help better guide the decision to perform chronic macular hole surgical repair. Although this study contained a limited number of patients, the data suggest that surgical repair in patients with chronic macular holes less than 3.4 years in duration and less than 1205 microns in size have a greater likelihood of type 1 closure. However, eyes with chronic macular holes of duration greater than 3.4 years still had a trend toward VA improvement, along with anatomic restoration following surgical repair, indicating that this technique should be considered in patients who might be otherwise be left to observation.

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