Original Article

Correlation of morphological characteristics of staphyloma with the structural and functional outcomes of myopic traction maculopathy after macular buckle surgery

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Purpose: To compare morphological features of staphyloma (type and grade) with structural and functional outcomes in 11 patients with symptomatic myopic tractional maculopathy (MTM) who underwent macular buckle surgery. **Methods:** A retrospective observational case series, where a chart review was conducted of the type (Curtin classification) and grade of staphyloma (USG B-scan based). Optical coherence tomography (OCT) macula analysis done preoperatively and postoperatively 1 and 6–8 weeks), Visual acuity was recorded in log mar. **Results:** With an average myopia of −10.35 D (−5 to −14.5 D), there were four patients with types II and IX staphyloma and seven with type I staphyloma. The average axial length was 28.6 ± 0.98 mm in type II/IX and 26.2 ± 0.8 mm in type I. Preoperative OCT features were outer retinal layer schisis (11), retinal detachment (foveal: 2, macular: 8), macular hole (lamellar: 3, full thickness: 4), and taut posterior hyaloid (3). Postoperatively, patients with type II/IX staphyloma had significant gain in visual acuity from 1.05 ± 0.3 to 0.74 ± 0.2 Log Mar. The structural features also responded better in patients with types II/IX staphyloma, with all patients having more than 90% reduction in schisis and retinal attachment at 6 weeks. Whereas only two patients with type I staphyloma had similar reduction in schisis at 6 weeks and only one had complete retinal attachment. **Conclusion:** In patients with MTM, the staphyloma characteristics preoperatively can help us prognosticate about structural and functional success after macular buckle surgery. In our small case series, patients with type II/IX staphyloma and larger axial length had better structural and functional outcomes.

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Pathological myopia is one of the major causes of visual morbidity worldwide, especially in Asian countries, with a prevalence of 10%.[1] Not all eyes with high myopia have a posterior staphyloma. But with increasing age and axial length, the staphyloma formation and progression increases.[2] Also the presence of staphyloma is mainly associated with progression of myopic maculopathy and vision loss in eyes with high myopia.[3]

Maculopathy in patients with high myopia can be attributed to three causes: atrophy, neovascularization, and traction.[4] Underlying staphyloma can lead to inability of overlying retina to stretch and adapt to the contour of staphyloma, leading to tractional changes at the posterior pole. The prevalence of myopic foveoschisis ranges from 14.65% to 34.4%, based on optical coherence tomography (OCT) findings in patients with high myopia.[5,6] Although this can be an underestimation as many of such patients are asymptomatic initially and OCT is not routinely performed in all patients with high myopia.

In a study correlating the staphyloma grade with the pathological changes at macula, it was seen that eyes with lower grade of staphyloma have a higher chance of pathological changes in macula and greater vision loss.[7]

It is known that highly myopic eyes with a posterior staphyloma have a higher probability of having visual disturbances.[8] Pathological myopia is characterized by constant axial elongation and gradual thinning of the posterior sclera, which may be due to the weakening of the mechanical properties of the sclera.[9]

Staphyloma was initially classified by Curtin in 1977 based on binocular stereoscopic ophthalmoscopy and fundus drawings of 250 cases. He classified staphyloma into primary (types I–V) and secondary (types VI–X), types I and II being the most common type of primary staphyloma.[10] Another study by Hsiang *et al*.[11] proposed to determine the implication of morphological characteristics in staphyloma on the subsequent development of myopic retinal degeneration. In their study on 208 eyes with high myopia, the authors observed that higher grades of staphyloma were associated with an increase in age. Eyes with type II staphyloma can progress to develop type IX staphyloma and associated worsening of myopic retinal degeneration.[11]

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Eyes with staphyloma are more likely to harbor pathological changes at the posterior pole with a higher incidence of tractional maculopathy and atrophy, leading to a drop in visual acuity compared to high myopic eyes without staphyloma.[11]

In a retrospective study, Oie *et al*. evaluated the morphology of staphyloma in 28 highly myopic eyes to see if it had any effect on the development of myopic tractional maculopathy (MTM). The authors found that eyes with type II staphyloma had a greater risk of developing macular hole retinal detachment compared to those with type I and III staphyloma. They further reported that the type of staphyloma did not affect surgical outcome after vitrectomy. As with vitrectomy, there is no change in the shape of staphyloma; thus, the outcome is varied.[12] In this study, vitrectomy was used as the surgical procedure.

Thus, in this study we propose to find that whether the type and grade of staphyloma has any correlation with the surgical outcome after macular buckle in patients with MTM.

Methods

This is a retrospective observational case series of 11 cases that underwent macular buckle surgery for symptomatic MTM. A chart review was done after getting clearance from the institutional review board and ethics committee. All patients underwent macular buckle surgery under general anesthesia by a single surgeon (PS),using a solid silicone T shaped macular implant (Morin–Devin wedge from France Chirurgie Instrumentation, FCI, France).

The surgical procedure is performing 360° conjunctival peritomy followed by tagging 4 recti muscles and identifying both obliques. Tenon's space is liberally exposed and solid silicone macular plate (Morrin wedge) is threaded onto the 2-mm solid silicone band (Devin Band). One end of this 2-mm solid silicone band is first passed under the lateral rectus muscle and then posteriorly under the inferior oblique muscle and brought to nasal side of the inferior rectus. Other free end is passed superiorly under superior rectus and oblique to be brought to nasal side of superior rectus insertion. The macular plate is slowly maneuvered along the contour of the globe under the lateral rectus moving towards the posterior pole. Using wide-angle viewing system under the operating microscope with 25G chandelier placed in parsplana, the posterior indentation of the macular plate was assessed and titrated and abutment of optic nerve head was avoided. The optic nerve and retina were carefully examined to ensure perfusion. With the optimum positioning at macula, the both end of the 2-mm band was trimmed and sutured to the sclera in their respective locations nasally. The anterior end of the macular plate was also trimmed and sutured underneath the lateral rectus muscle. Conjunctiva was pulled over the globe with the tenon's and sutured carefully.

The evaluation included recording of the following features such as age, gender, refractive error, axial length (USG), best-corrected visual acuity (BCVA) preoperatively and postoperatively. Type and grade of staphyloma and structural changes at macula were studied preoperatively and postoperatively. All patients underwent Swept-Source OCT postoperatively at day 5 and at 6–7 weeks, along with color fundus photo, fundus drawing for documentation, refraction, IOP check, and complete ocular examination.

The grade of staphyloma was measured using ultrasound images with axial scan in relation to optic nerve head and classified on the criteria of Steidl and Pruett.[7] Staphyloma was graded from real-time B-scan as mild (1–2 mm), moderate (2–4 mm), severe (4–6 mm), and very severe (>6 mm).

The type of staphyloma was determined by an examiner using binocular indirect bio microscopy and corroborated with color fundus photo stereoscopic evaluation. The types were classified on the basis of Curtin classification (type's I–X).[10] For determining the type and grade of staphyloma, OCT analyses were done by both examiners (PS and GS) independently with similar inter-observer findings and good repeatability. In case of any discrepancy in observation, help of a senior retina consultant (PB) was taken.

Swept-Source OCT (SS-OCT DRI OCT-1 Atlantis; Topcon Singapore Medical Pte Ltd) was conducted in most of the patients preoperatively and in all patients postoperatively. A few patients had preoperative spectral-domain OCT done recently when they came to our institute for further management; thus, it was not repeated. The following features were analyzed pre- and postoperatively: taut posterior hyaloid, internal limiting membrane (ILM) detachment, schisis (inner/outer/both), macular hole (full thickness/lamellar), neurosensory detachment (foveal/macular), subretinal fluid (SRF), and choroidal neovascular membrane. We manually measured the amount of outer retinal schisis and subfoveal SRF at the approximate same reference point pre- and postoperatively using calipers on OCT scans.

In this study, we tried to analyze if there is any relationship between the morphological characteristics of staphyloma, the structural (OCT), and functional (visual acuity) changes, before and after surgery in patients undergoing macular buckle.

Results

Mean age in the series was 50.72 years (35–65 years) and average myopia was −10.35 D (−5 to −14 D) as calculated from patients with phakia. The average axial length was significantly larger (P = 0.002) in patients with type II/IX staphyloma (28.6 ± 0.98 mm) compared to patients with type I staphyloma (26.17 ± 0.78 mm). The average duration of preoperative symptoms was 34.8 days, with a median value of 21 days. The baseline features are given in Table 1. Type II/IX staphyloma was observed in four patients and seven patients had type I staphyloma. The preoperative visual acuity was comparable (P = 0.13) in eyes with type I staphyloma (LogMar 1.29 ± 0.14) to those with type II/IX (LogMar 1.05 ± 0.33). Postoperative improvement in vision was observed in all patients with type II/IX staphyloma with LogMar visual acuity of 0.74 ± 0.24. However, in patients with type I staphyloma, there was minimal improvement in two cases and no improvement in five, mean LogMar being 1.29 ± 0.41. This difference was significant between the two groups (P = 0.004).

Structural changes were documented on OCT preoperatively [Table 2]. After surgery, change in the retinoschisis height and SRF was noted. The postoperative changes were documented at 1 week and then at 6–8 weeks. Three of four patients with type II/IX staphyloma and only one with type I had >90% reduction in schisis at 2 months. Resolution of SRF was complete in all patients with type II staphyloma whereas most of patients with type I had <90% reduction at 2 months [Fig. 1]. Macular hole closed in two cases of type II staphyloma and only in one of two in patients with type me staphyloma. In Fig. 2 there is a representation of three cases with type II (a), type IX (B) and type I (C) staphyloma and there preoperative features and resolution of features of MTM after macular buckle surgery.

Discussion

Posterior staphyloma (PS), which is associated with pathological myopia, affects all the layers of the ocular coat including sclera, choroid, and retina.[11,13] Myopic maculopathy is sequential to the

Table 1: Preoperative baseline features of the patients with myopic tractional maculopathy who underwent macular buckle

Age (years)	Gender	Lens status	Refractive error (diopter)	Axial length (mm)	Type of staphyloma	Grade of staphyloma	Preop VA (LogMar)	Postop VA (LogMar)
37	M	Phakic s/p lasik	−5.5	26.5	1	1	1.3	1.3
64	F	PP	NA	26	1	1	1.5	1.3
59	F	PP	NA	26.1	1	1	1.3	1.3
48	M	Phakic	−12	29	2	1	1.3	0.9
47	F	Phakic	−13	27.7	2	1	1	0.6
43	F	Phakic	−11.5	29.8	9	1	1.3	1
48	F	Phakic	−14.5	26	1	4	1.3	1.7
35	M	Phakic	−11	25	1	1	1	0.8
65	F	PP	NA	27.9	2	2	0.6	0.48
60	F	IMSC	−5	27.4	1	1	1.3	1.3
52	M	PP			1	4	1.3	0.8

*M: male, †F: female, ‡PP: pseudophakic, §NA: not available

Table 2: Preoperative OCT features in patients with pathological myopia

	Type I staphyloma (7)	Type II/IX staphyloma (4)
Outer retinal schisis	7	4
Macular retinal detachment	5	3
Foveal retinal detachment	1	1
Full-thickness macular hole	2	2
Lamellar macular hole	3	
Taut posterior hyaloid	2	1

progression of the posterior staphyloma. It can have atrophic or subsequent neovascularization component, which can be managed medically. However, the second arm of the myopic maculopathy comprises MTM, which when symptomatic and progressive needs surgical intervention. The choice of surgery should be guided by the primary tractional force leading to maculopathy. Three forces are acting on the retinochoroidal complex in a myopic eye: tangential forces of taut ILM or epiretinal membrane, anteroposterior traction by hyaloid, and posterior scleral ectasia,[14] though all may be present in the same eye. But in patients with greater axial length and staphyloma, conventional vitrectomy has high failure rate and higher incidence of re-surgery.[15]

We have noted in our unpublished case series that macular buckle surgery has encouraging results. Both anatomical and functional outcomes and MB surgery could be considered as a viable option in cases of symptomatic MTMs associated with posterior staphyloma. Hence, we wanted to study why certain morphology of it was having favorable outcome, both structural and functional, after surgery. We categorized our staphyloma types according to the Curtin's classification. This original classification of staphyloma type by Curtin has been reclassified by Ohno and Matsui. They did MRI of the globe and gave a morphological description of staphyloma. The type I staphyloma was described as a wide macular type and type 2 as a narrow macular type.[16]

In the presence of staphyloma, the macula has a concave contour. After macular buckle surgery, the macular surface changes to a planoconvex shape. This will relieve the anteroposterior vitreoretinal traction and hence overcome the geometric imbalance that exists between the neurosensory retina and retinal pigment epithelium–choroid–sclera complex, facilitating adhesion between the tissues.[17,18] In patients with staphyloma, the radial force induced by the epiretinal membrane or taut hyaloid on the retina is directed inward toward the center of the eye. To explain this, we put an analogy of action force in a conventional scleral buckle, where there is reversal of these forces [Fig. 3]. The convex radius of curvature of the peripheral retina on the scleral buckle is much smaller than the concave radius of curvature of the eye. The magnitude of the radial outward force promoting retinal reattachment with a scleral buckle is larger than the original radial inward force tending to detach the retina.[19] Thus, as type II staphyloma are narrower than type I, the inward acting forces (preoperatively) are counteracted better after placing buckle. This probably explains why patients in the type II group had better structural and functional outcomes.

Further, in our study, though most of the eyes had grade I staphyloma, the axial length of type II/IX group was significantly longer than that in the type I group. This also goes in favor that these eyes will have a better indentation after surgery and a better surgical outcome. Another possible reason is that the Type I staphyloma involve the optic nerve and macula, buckle when placed does not abut on the optic nerve thus will produce a shallow indent. Whereas in type II/IX staphyloma involving the macula the buckle element covers them better and indent can be titrated to a larger extent as this does not pose danger of impingement to optic nerve.

Macular hole closed in all cases after macular buckle in this series. Buckle surgery has around 70-100% closure rate as compared to vitrectomy (73.3-83.3%).[17,20-22] This is because buckle takes care of the centripetal traction due to vitreous, antero-posterior traction of staphyloma as well as the tangential traction of ILM by altering the globe contour to convex and decreasing staphyloma height. Vitrectomy has lesser rate of hole closure as it does not affect the staphyloma morphology and ILM peeling in thinned out retina has further risk of idiopathic macular hole.

Oie *et al*. tried to correlate the morphology of staphyloma with the pattern of MTM and results after vitrectomy. They concluded that eyes with local posterior pole staphyloma had a higher rate of progression to macular hole retinal detachment than the eyes with diffuse posterior staphyloma. The possible reason for this is that in a localized staphyloma the tangential vector force by the posterior hyaloid phase is stronger as the wall of the staphyloma is steeper compared to diffuse staphyloma that are shallower; thus, the tangential forces are weak. Their study patients underwent vitrectomy and it was found that morphology has no relation with the surgical outcome. As with vitrectomy, there is no change in the shape of staphyloma; thus, the outcome is varied.[12]

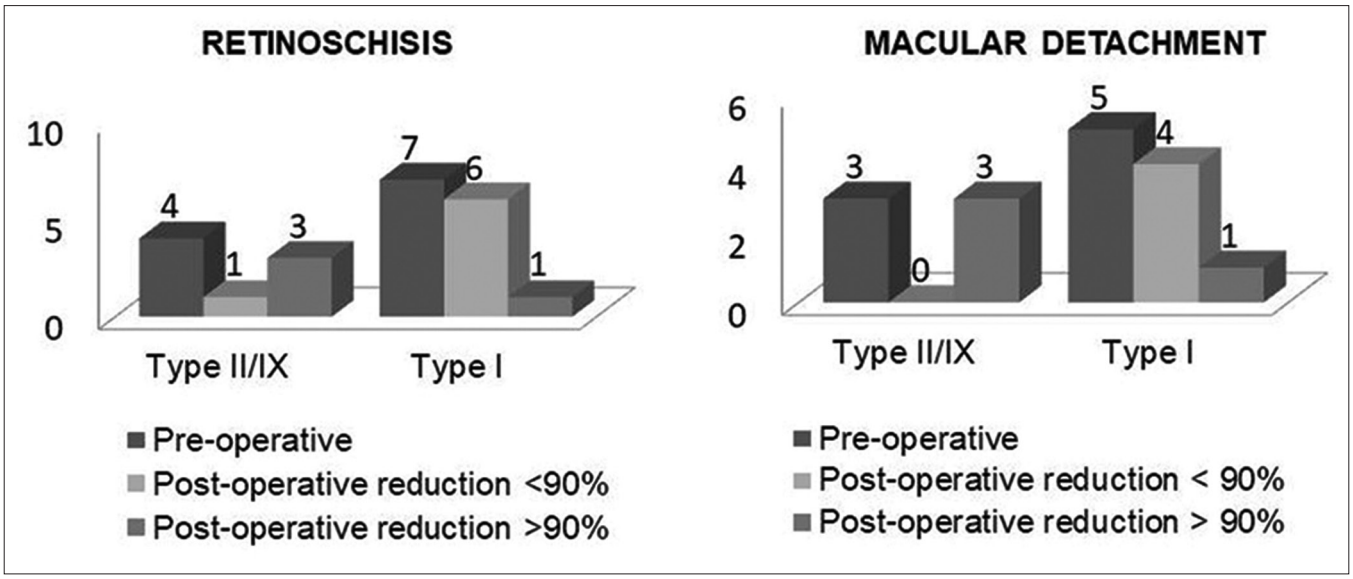

Figure 1: Bar graph showing the number of cases with retinoschisis and retinal detachment preoperatively and their resolution pattern at 6 weeks postoperative period

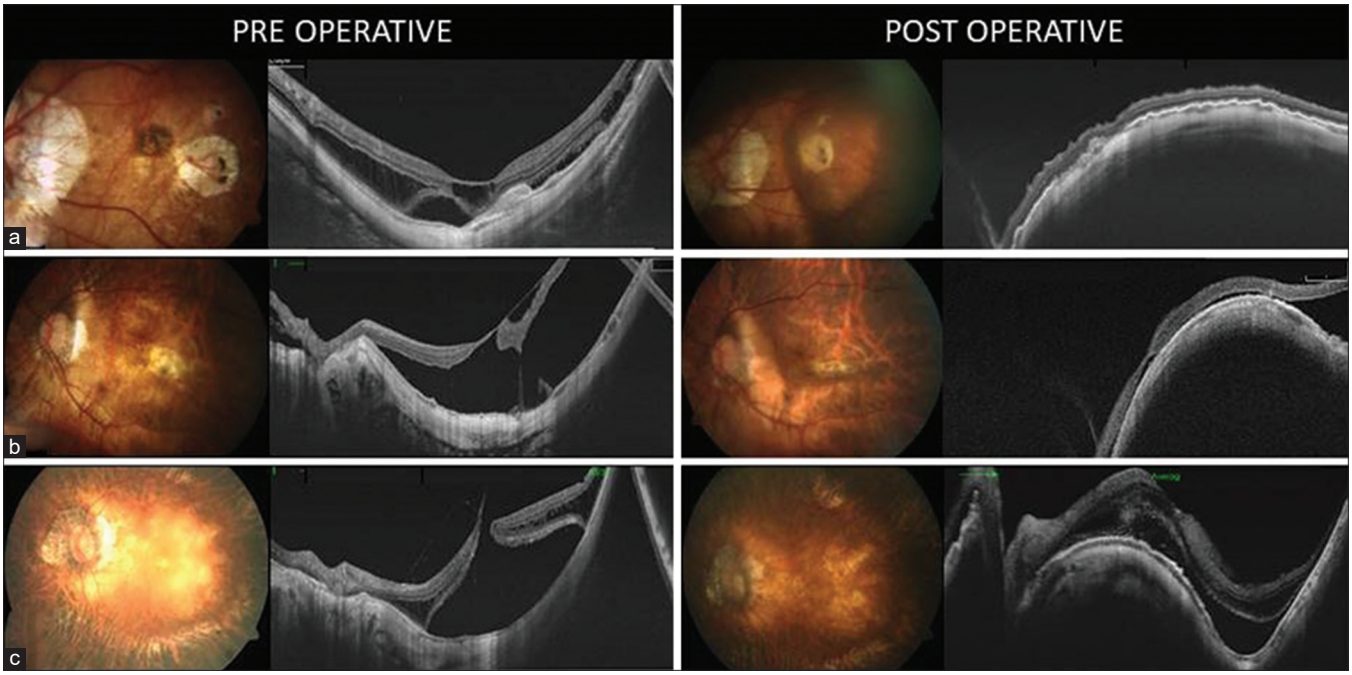

Figure 2: (a) Type II staphyloma with foveal retinal detachment (RD) and outer retinal schisis with lamellar macular hole. Post operative resolution of schisis and retinal attachment with hole closure. (b) Type IX staphyloma : macular RD, lamellar hole and retinal schisis. Post surgery resolution of schisis, hole closure with retinal attachment, trace fluid temporally reabsorbed on follow up. (c) Type I staphyloma with macular RD, full thickness hole. Post surgery the buckle indent is seen with hole closure but there is persistent fluid at macula

Though numerous studies have evaluated the role of vitrectomy or macular buckle or combined procedure in treatment of MTM, none of them actually analyzed the morphology of staphyloma and whether this has any implication on surgical outcome. A few studies do mention the presence of staphyloma in patients with MTM but did not analyze any relation of the outcome with the staphyloma type and grade. In a review article on macular buckle, it was reported that vitrectomy is a good option in patients with myopic foveoschisis with or without detachment in the absence of macular hole. In cases of MTM with macular hole retinal detachment and staphyloma, macular buckle had better surgical outcome, better gain in visual acuity, and lesser need for re-surgery.[23]

The limitation of this study is a smaller sample size. Probably with a larger sample size, it would be more definitive to comment on the prognostication of the surgical outcome with staphyloma type and grade. Presence of underlying chorioretinal atrophy is likely to influence the visual recovery post-surgery in either group, which was not looked at in our series. We did not conduct MRI in our cases, which would have

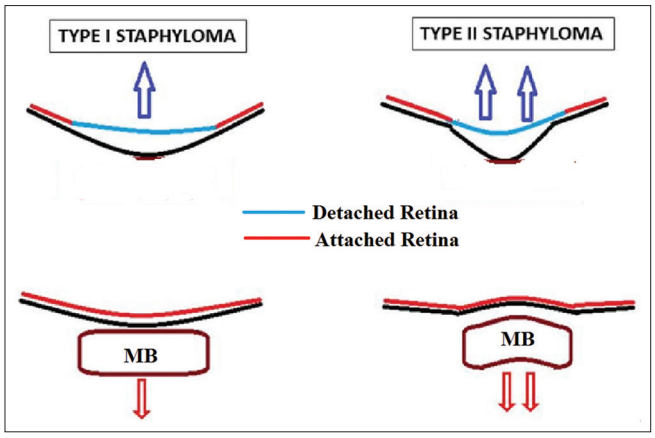

Figure 3: Schematic representation of possible mechanism by which the buckle alters forces for retinal attachment. At the staphyloma buckle reverses the direction of inward force on retina to an outward force. As force at an area is inversely related to radius, thus it will be larger for Type II/IX staphylomas (narrow macular type)

added more information on the morphology of staphyloma. Also, most of our patients fall into three types of staphyloma, so we cannot comment how other types affect the surgical outcome. Short term follow up is also an issue.

Conclusion

The detailed assessment of morphological type of staphyloma and the axial length would help the surgeon in prognosticating the possible outcomes after macular buckle surgery in MTMs. Understanding the type of staphyloma would definitely play an important role in the selection of cases for surgery, deciding the type of surgery and probably the overall outcome of the surgery. In our small case series, patients with type II/IX staphyloma and larger axial length had better structural and functional outcome after surgery compared to those with type I staphyloma.

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Conflicts of interest

There are no conflicts of interest.

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