

TREATMENT OF PAEDIATRIC TRAUMATIC MACULAR HOLES

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SUMMARY

Purpose: To report the results of treatment of the traumatic macular holes (TMH) in four children.

Methods: Retrospective study analyzed data of 4 children, males with a mean age of 12.3 years (range, 9–17 years), with diagnosis of TMH. All patients suffered a blunt trauma of the eye during the sport activities. The symptoms of three patients began after being hit to the face with a soccer balls, one boy was hit to his eye by a tennis racket. Right eyes and left eyes were occurred identically. All patients were followed with ophthalmic examination, fundus photography and optical coherence tomography (OCT). One patient aged 10 years two weeks after blunt trauma with a soccer ball achieved spontaneous closure of TMH. Three patients aged nine to 17 years with TMH underwent surgical repair between September 2007 and May 2012 with three-port vitrectomy. After induction of posterior vitreous detachment vitrectomy with or without internal limiting membrane (ILM) peeling and gas or silicone oil injection were performed followed by prone positioning of head for ten days. Silicon oil was in an only patient removed within 3.5 month.

Results: All four macular holes were closed successfully. Follow-up period was from 10 to 31 month (ranged, 20 month). There were no reoperations. There were no surgical complications during follow-up period. Visual acuity (VA) improved in all eyes. In spontaneously closed TMH was VA improved from 0.5 to 1.0. In surgically treated group VA improved from initial 0.016 to 0.1 (ranged, 0.061) to final 0.25 to 0.5 (ranged, 0.36).

Conclusion: Pars plana vitrectomy is a safe method for treatment TMH in children without tends to spontaneous closure of TMD in OCT imaging. Predisposition for TMH in population south-east Asia is suspected.

Key words: traumatic macular hole, children, optical coherence tomography, vitrectomy, spontaneous closure

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INTRODUCTION

Macular hole (MH) is a circular or oval lesion of the neuroepithelium of the retina throughout the full thickness in the centre of the macula, usually accompanied by a ring of subretinal fluid in the surrounding area of the defect, which results in a reduction of central visual acuity of the affected eye. It is estimated that more than 90% of diagnosed MHs are represented by idiopathic MH (IMH), which afflict predominantly post-menopausal women. MH as a complication of high myopia and traumatic macular holes (TMH) represent only a small proportion of all MHs. TMH, as first described by Knapp (15) in 1869, is one of the possible retinal complications of a blunt trauma to the eye, similar to commotio retinae (Berlin's edema), retinal necrosis, retinal haemorrhage, ruptures of ILM (Hirata), ruptures of the choroïd in the region of the macula, retinal ruptures or rhegmatogenous retinal detachment on a background thereof, and is most frequently described in the case of young, active sporting men (1-6, 8-20, 22-28, 30-35). Dangerous sports from the perspective of causing TMH include especially ball games (football, baseball, tennis). Recently retinal defects of the macula caused by accidental strike by laser pulse, which generates plasma and causes tissue disruption (1064 nm neodymium: yttrium-aluminium-garnet (Nd: YAG) laser used in ophthalmology or dermatology, or 755 nm Alexandrite laser used for correction of pigment lesions in dermatology), described by persons who have worked with lasers as protective aids, negligent users or service technicians,

have been classified together with TMH (7, 21, 29).

Although the rapid development and spread of display methods, in particular optical coherence tomography (OCT) as methods enabling potential changes, has led to a more detailed understanding of TMH caused as a result of contusion of the eye in the last decade, in contrast with IMH there is still no uniform consensus on its pathogenesis and development. The most widespread explanation is a combination of mechanisms which may differ in the case of each injury in their degree of application, such as sudden front-to-back deformation of the bulb, with flattening of the posterior pole of the eye, where layers with varying elasticity and vulnerability meet in close contact (posterior hyaloid membrane, ILM, neuroretina, choroïdea with retinal pigment epithelium (RPE) and sclera), varying degrees of Berlin's edema or post-contusion retinal necrosis or retinal haemorrhage. The result of this is that some TMHs are found immediately following injury with or without the use of OCT, whilst others are diagnosed only later within the framework of monitoring. For the same reason, initial best corrected visual acuity (BCVA) may be even substantially worse than 6/60 (0.1), as we know from the 3rd and 4th degrees of IMH according to Gass. The natural development of the finding following the onset of TMH is also not unequivocal. TMH, similar to IMH, may persist and require surgical intervention for anatomical and functional rehabilitation. However, spontaneous closure of TMH is also possible. This has been described within an interval ranging from a number of days up to several months (1, 5, 20, 22, 26, 28, 30-32), especially in the case of small

TMHs with a size of 0.1-0.2 papillary diameter (PD), even if it was initially accompanied by localised flat retinal detachment (1, 20). It is also necessary to reckon with the fact that TMH may be an amblyogenic factor in children aged under 7 years. For all of the above reasons, approaches towards the treatment of TMH differ. The majority of authors agree only that the most reliable guarantee of anatomical closure of TMH is pars plana vitrectomy (PPV) with intraocular tamponade, with careful removal of the posterior hyaloid membrane of the vitreous body in the posterior pole of the eye, because in young individuals this adheres especially strongly, and with a downward positioning of the head for at least one week following surgery. With regard to other aspects of PPV (timing, facilitation, ILM peeling, adjuvant agent, tamponade), there are differences of opinions and recommendations. Similarly as in the case of IMH, closure of TMH is a good starting point but by no means a guarantee of improved function of the eye, due to the different degree of in particular post-traumatic, but also postoperative changes of the eye.

METHOD AND PATIENTS

During the period 2007-2012 we diagnosed TMH in 4 minors, all boys, aged 9, 10, 13 and 17 years. Injury to the right and left eye was represented equally. In all cases the injury was caused during sport, in three of the boys (9, 10 and 17 years) contusion of the eye by a football, one boy was hit in the eye with a tennis racquet. In all boys the injury to the macula was isolated, and there was no finding of any other contusion of the eye caused by ocular pathology. Classic three-port PPV under general anaesthesia was indicated for 3 boys, with careful removal of the posterior hyaloid membrane, and ILM peeling was performed on one patient. 20% SF6 was used twice as a tamponade, and in one case silicone oil, which was subsequently removed after 3.5 months. Spontaneous healing of TMH occurred in the ten year old boy following contusion by a football during the course of the second week following the injury, during the course of the recommended regimen of rest and preparation for in-

tended PPV. The findings of all patients were monitored by ophthalmological examination, photography of the fundus and OCT. An overview of the patients is presented in table 1.

Using the key term "traumatic macular hole", we searched in the PubMed database for links to studies published on the issue in question in journals index MEDLINE, including a focus on the stated numbers of patients and geographical localisation of the stated workplaces of the first authors. In the stated cases we worked only with the numbers of patients presented in the abstract. An overview from 1995 is presented in table 2.

RESULTS

In all patients the macular hole was closed and central visual acuity improved. Initial BCVA was substantially worse in the group treated surgically, ranging from 1/60 (0.016) to 6/60 (0.1), see table 1, in the patient healed without surgical treatment this was 6/12 (0.5). Postoperative BCVA improved to 6/24 (0.25) – 6/12 (0.5), in the case of spontaneous healing of TMH it improved to 6/6 (1.0). We did not observe any early or later postoperative complications. The average observation period was 20 months.

DISCUSSION

The incidence of TMH worldwide in children and young adults is linked primarily to contusion injuries to the eye caused during ball games, in which suitable protective equipment is either not used or does not exist, or if contact of the head with the ball is actually required by the game itself. This need not necessarily concern direct impact from smaller balls (baseball, tennis, golf, squash) (1, 2, 8, 10, 12-14, 22, 23, 27, 31), impact of the face with a larger surface of a ball is widely represented (football, volleyball, basketball) (2, 4, 5, 8, 20, 27, 28, 30, 31, 35). Contusions with other flying or launched objects (bottle corks, stones, rubber bands, paintballs) or blows (fist, stick, fall onto object, traffic accidents) also occur to a lesser extent. Wounds to the eye socket connecting trauma with thermal coagulation (retino-

Table 1 Patient data

no.	Age (years)/sex	Duration of TMH (weeks)	Source of trauma	Associated traumas	Closure of TMH	No. of surgical procedures / tamponade	Visual acuity			Observation period (months)
							initial	final	Other eye	
1	13/M	2	Tennis racquet	No	Yes	2/SO, discharge of SO	0.067	0.5	1.0	17
2	9/M	30	Football	Shifts of RPE	Yes	1/SF6	0.016	0.25	1.0	10
3	10/M	2	Football	No	Yes	0/-	0.5	1.0	1.0	31
4	17/M	1	Football	Shifts of RPE	Yes	1/SF6	0.1	0.33	1.0	23

Key: M – male, SO silicon oil, RPE – retinal pigment epithelium, SF6 – hexafluorosulphide

**Table 2. Literature according to number of patients and year of publication.
2a) chronologically**

Author	Country of first author	Year of publication	Number of patients
Rubin (27)	USA, Baltimore	1995	12
Yanagia	Japan, Asahikawa	1996	20
García-Arumé (8)	Spain, Europe	1997	14
Kusaka	Japan, Osaka	1997	3
Barreau	France, Europe	1997	5
Margherio (23)	USA, Michigan	1998	4
Amari (2)	Japan, Matsumoto	1999	23
Chow (12)	USA, Michigan, Canada	1999	16
Parmar (26)	Great Britain, Europe	1999	1
Mitamura (22)	Japan, Sapporo	2001	11
Yamashita (31)	Japan, Kagoshima-shi	2001	8
Johnson (13)	USA (multicentric)	2001	25
Kuhn	USA, Alabama	2001	17
Hwang	Taiwan	2001	1
Yeshurun (32)	Israel	2002	1
Yamada (30)	Japan, Kansai	2002	3
Krásnik (17)	Slovakia, Europe	2002	6
Ikeda	Japan, Nishinomiya	2002	1
Wachtlin (33)	Germany, Europe	2003	4
Tafoya	USA, Houston	2003	3
Hirata (10)	Japan, Kumamoto	2004	2
Yang	Taiwan	2004	1
Korda (16)	Czech Republic, Europe	2005	6
Flynn	Ireland, Europe	2005	1
Carpineto	Italy, Europe	2005	1
Chen Y.P.	Taiwan	2005	8
Oehrens (25)	Belgium, Europe	2006	1
Lai (20)	USA, Michigan	2006	1
Arevalo (3)	Venezuela (multicentric)	2007	10
Wu (35)	USA, Michigan	2007	13
Brasil (6)	Brazil	2007	2
Kim	Korea	2007	5
Bosch-Valero (5)	Spain, Europe	2008	2
Chen H.	China, Guangdong	2008	1
Querques	France, Europe	2008	1
Li	China, Beijing	2008	48
Huang (11)	China, Guangzhou	2009	73
Weichel (34)	USA, Washington	2009	17
Valmaggia	Switzerland, St. Gallen, Europe	2009	1
Lange	Switzerland, Lucerne, Europe	2009	1
Wykoff	USA, Miami	2010	1
Khoramnia	Germany, Europe	2010	2
Nasr (24)	Greece, Europe	2011	1
Xu	China, Shenyang	2011	16

Tab. 2 - continue...

Author	Country of first author	Year of publication	Number of patients
Thapa	Nepal	2011	5
Kimura (14)	Japan, Kanazawa	2012	3
Aalok (1)	India	2012	1
Filippi Sartori (28)	Brazil	2012	1
Ghoraba (9)	Egypt	2012	22
Azevedo (4)	Portugal, Europe	2013	4
Sanjay	Singapore	2013	1
Karaca	Turkey	2013	1
Yonekawa	USA, Boston	2013	1
Total			432
2b) geographically			
Japan			74
China			138
Taiwan, Korea, Singapore			16
Total SE Asia			228
Europe			51
USA			110
SE Asia			228
Other			43
Total			432

pathia sclopetaria), as well as explosions and their pressure waves, thankfully occur only sporadically as a source of TMH in peacetime conditions (34). TMH following contusion with a football predominates in our cohort of paediatric patients. The incidence of TMH following contusion of the eye is uncertain with regard to the time factor. Although it is assumed that the majority of TMHs originate immediately following the blow to the eye, the degree of latency before the ophthalmological examination is performed, ideally together with OCT, provides room for speculation. The decrease in visual acuity following contusion of the eye is frequently linked not only to initial Berlin's edema, but also for example to haemorrhage into the anterior chamber of the eye, and TMH therefore cannot be determined anamnestically. Even the largest cohorts of patients (see table 2), which as is evident in the case of TMH represents maximally tens of patients, are often created only following the recommendation of individual patients to larger centres for treatment or as multicentric studies. Examination by OCT is thus performed most often with an interval of several days, whilst examination on the first day following the injury (e.g. Yamashita (2002), Lai (2006) (20, 31)) is not common. Published performance of OCT on the day of injury with demonstration of TMH and other monitoring finding is rare (Oehrens (2006), Bosch-Valero (2008 (5, 25)). Early monitoring of the findings by means of OCT demonstrates that even TMH with manifest retinal detachment in the OCT image may reattach and spontaneously heal (Lai (2006), Aalok (2012), (1, 20). The question therefore arises as to whether small TMH in

the early phases following injury, masked by Berlin's edema, may be a more common finding than is actually diagnosed, and whether early performance of OCT only on the basis of a deterioration of BCVA following contusion of the eye would provide an answer to this question. If we start out from this assumption, the further development of the finding could be influenced also by appropriate post-traumatic conservative recommendations and treatment such as one week of strict rest regimen (at home, in bed, on back) and medication (anti-edematous and anti-inflammatory). Conservative therapy is not stated by the majority of authors. In the case of our third patient (see table 1, fig. 3), TMH spontaneously reattached within the course of two weeks of conservative therapy. There is a question as to whether the spontaneous reattachment of TMH was contributed to also by "tamponade" of the still attached vitreous body, which always adheres firmly in children and may have generated gravitational force on the edges of the TMH in the ten year old boy upon positioning on his back.

The timing of the intervention therapy of TMH was significantly influenced partially by the demonstrated fact of the possibility of spontaneous reattachment of TMH, and partially by the fact that we know from the treatment of IMH that prolonged retinal detachment in the region of the edge of the macula, compared to fluid cuff, causes long-term damage to the retina, as well as the fact that PPV has an acceptable degree of surgical risk in children and young adults. There are advocates of explicitly early PPV (within 9 days following injury, Azevedo (4)), slightly deferred PPV (1-6



Fig. 1

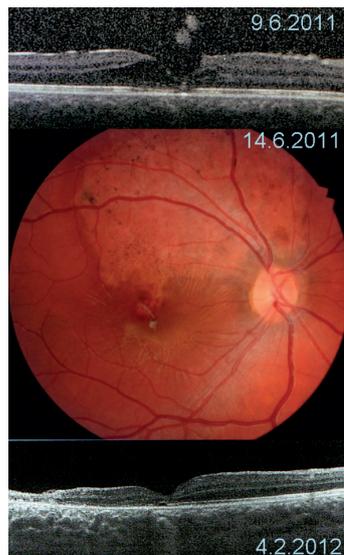


Fig. 2

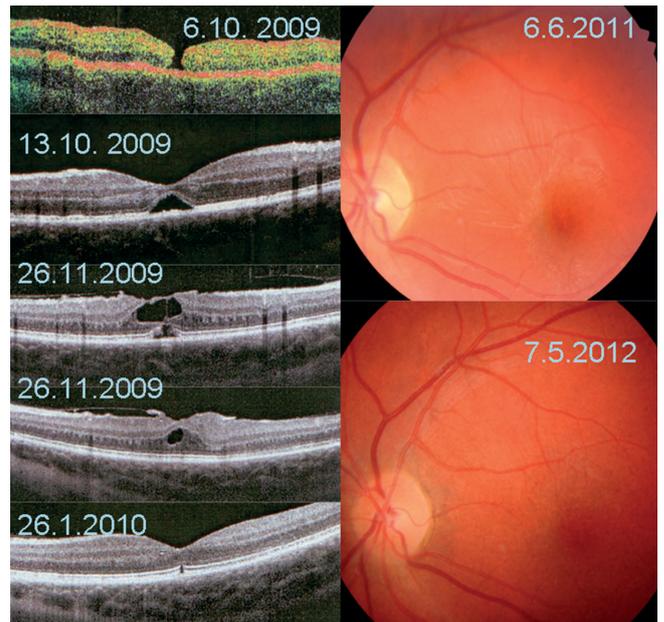


Fig. 3

weeks following injury, García-Arumí (1997) (8)), and advocates of a period of 3-4 months of conservative observation first of all (Mitamura (2001), Wachtlin (2003) (22, 23)), within which a number of the patients may spontaneously heal. Often, however, the interval between the injury and the operation depends on how quickly TMH is diagnosed and the patient is recommended to a specific centre, and this ranges from a number of days to several months (Johnson (2001), Wu (2007) (13, 35)). Krásnik (17) stated that early PPV had far better anatomical and functional results than if deferred for 2-3 months. The patients in our group represent all the above options, two of the three patients who reported directly to the clinic were operated on early, one healed spontaneously. The third operated patient was diagnosed on the basis of a preventive examination by a paediatrician with an interval of several months, and although TMH was healed and visual acuity improved, the patient had the worst resulting BCVA of the entire cohort. Surgical treatment of TMH by the method of PPV and internal tamponade has several different modifications. All the authors concur that careful removal of the posterior hyaloid membrane, which adheres very strongly in young individuals, is of key importance. The possibility that this adhesion may be reinforced further still in places of contusion injuries to the retina has not been excluded (Kimura (2012) (14)). For this reason, visual techniques are used for easing vitrectomy (triamcinolone acetate, Kimura (2012) (14)), indocyanine green (ICG) for staining the ILM in order to facilitate peeling in the region of the macula (Hirata (2003), Kimura (2012) (10, 14)), similarly trypan blue (Korda (2005) (16)), and autologous plasmin has been used in order to facilitate the actual vitrectomy for detachment of the posterior vitreous surface (Margherio (1998), Chow (1999), Wu (2007) (12, 23, 35)). In order to improve the additional healing of

the edge of TMH, thrombocyte concentrate has been used a number of times (García-Arumé (1997), Wachtlin (2003) (8, 33)), as well as autologous serum (Johnson (2001) (13)) or transforming growth factor (TGF- beta 2) (Rubin (1995) (27)). The effectiveness of the factors used for additional healing of the edge has been disputed by studies in which these substances were not used (Amari (1999), Chow (1999) (2, 12)). All types of today's regularly used materials have been used as intraocular tamponade, perfluoropropane (Johnson (2001) (13)), hexafluorodisulphide (Amari (1999), García-Arumí (1997) (2, 8)), silicone oil (Ghoraba (2012) (9)),

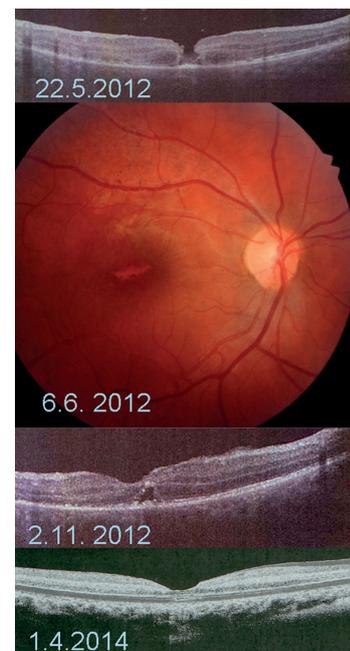


Fig. 4

as well as air (Hirata (2004) (10)). Amari (1999) (2) demonstrated that surgical treatment of TMH is successful even without the necessity of ILM peeling, vitrectomy facilitators or additional healing, and with only brief tamponade using hexafluorosulphide, but extended the period of recommended face-downward positioning from one week to two in comparison with other authors. ILM peeling is considered to represent a factor increasing the effectiveness of closure of TMH (10, 14, 16), a question exists as to what extent it merely safely ensures the complete removal of all parts of the posterior hyaloid membrane from the region of the macula. In our cohort of patients hexafluorosulphide was used twice, silicone oil once, and ILM peeling was performed only on the patient with long-term persisting TMH. We recommend face-downward positioning for 7-10 days in the initial postoperative period, and then subsequently when in lying position throughout the duration of tamponade in the eye (i.e. do not lie on back). We confirm that it is possible to achieve the desired result by various methods. At least one third of the patients in the cited publications (see table 2) are probably from Southeast Asia. Could TMH be under-diagnosed in the rest of the world? This reason could ensue for example from the customs of the ophthalmological therapeutic procedure in patients following early contusion of the eye by not inducing artificial mydriasis, and conversely

by establishing a minimum of one week's bed rest. In the case of the unavailability of detailed display of the fundus using OCT, a range of especially small TMHs could heal undetected. Or is TMH diagnosed well worldwide, only with a higher frequency of incidence in Southeast Asia? Is it caused by the large percentage of the population who play ball games such as football and baseball, or is there an ethnic risk for the incidence of TMH? We are not aware of any discussion concerning the issue of potential ethnic risk, and have no answer to this. All of our four patients are originally European.

CONCLUSION

We indicated PPV with internal retinal tamponade on the basis of the result of OCT examination, without the tendency towards spontaneous closure of TMH. In all the children we recorded anatomical success and a satisfactory functional result. If the retina does not have a tendency towards early spontaneous healing according to monitoring by means of OCT, PPV performed within one month of injury is the best option for treatment.

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