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Posturing after Macular Hole Surgery: A Review

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Abstract
Since the first reports on surgical repair of macular holes, postoperative face-down posturing (FDP) has been part of the management regime. However, prone positioning is unpleasant for patients, and has adverse effects. Over the last decade some vitreoretinal surgeons have reduced the duration of FDP, or even abandoned it altogether. There have been few non-randomised, and even fewer randomised trials addressing this controversy. With high success rates for macular hole surgery and multiple different surgical strategies such as internal limiting membrane peeling, combining macular hole and cataract surgery, and different durations of gas tamponade, analysing the effects of individual factors is difficult. This paper discusses the mechanisms of surgical repair as well as the role of postoperative FDP, and reviews the studies that have attempted to determine its effect on the success of macular hole surgery.

Introduction

Surgery to close macular holes developed from the necessity to manage retinal detachments associated with posterior pole breaks [1–3]. Although many advances have been made since those initial days, the concepts of vitrectomy and tamponade have remained. The early proponents of this technique introduced face-down posturing (FDP) postoperatively for their patients [3], with more defined periods of FDP being suggested subsequently [4, 5]. This remained part of the treatment for macular holes for many years. However, FDP was first challenged in 1997 [6], and this debate still continues amongst retinal surgeons. This paper reviews what is known about the effectiveness of postoperative FDP for macular hole repair.

Macular Hole Surgery

Anteroposterior traction secondary to abnormally persistent vitreofoveal attachment, in combination with tangential contraction of the perifoveal vitreous cortex are thought to initiate macular hole formation [7–10]. The first series attempting to address this by removal of the

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posterior cortical hyaloid was by Kelly and Wendel [4] in 1991. The main aim of surgical intervention is to relieve traction and halt intraretinal hydration and the subretinal accumulation of vitreous fluid through the hole [11]. Core vitrectomy and removal of epiretinal membranes achieves this. In addition surgical intervention stimulates reparative healing mechanisms. It is thought that peeling the internal limiting membrane (ILM) reduces tangential traction by both removing residual vitreous cortex and any substrate for myofibroblast growth, which may contract and prevent closure of the hole [12]. ILM peeling may stimulate local glial repair by upregulating growth factors [13]. Although some groups have found no improvement in anatomical or visual outcome with ILM peeling [14], others have shown significant improvements [15–17]. Randomised controlled trials have shown a significantly higher macular hole closure rate with ILM peeling [18, 19].

The concept of tamponade developed from the first operations for macular hole closure [4]. Air tamponade was shown to be less effective than long-acting gases; Thompson et al. [20] showed a 97% closure rate with 16% perfluoropropane (C_3F_8) compared with 53% with air. Other tamponades were suggested, particularly silicone oil, which had been used for macular hole retinal detachment repairs [21] with good anatomical outcomes. Primary macular hole closure with silicone oil tamponade reaches 80–97% [22–25]. Although some indicate better visual outcomes than with long-acting gas [22], others suggest visual outcomes are poorer with oil tamponade [23, 24, 26]. This may be due to oil toxicity, or may reflect selection bias in these retrospective series. The modes of action of tamponade include: providing a scaffolding for reparative glial tissue, particularly Müller cells and fibrous astrocytes, across the macular hole [27, 28]; prevention of subretinal hydration with vitreous fluid ('macular isolation') [11]; maintaining a mechanical force to keep the macular hole against the retinal pigment epithelium, and opposing any tractional forces which may hold the hole open [29, 30]. The actual effect of intraocular gases may lie in the fluid-gas surface tension rather than any buoyancy effect [31]. This is supported by the success of silicone oil, which has a greatly reduced buoyancy compared with gas tamponade [25].

Why Bother with FDP?

FDP has been considered an integral part of macular hole surgery. This is based on studies that have shown that short-term tamponades such as air [20] have significantly reduced success rates of closure. Indeed some authors have suggested that the longer the duration of gas tamponade, the better the results [30]. This principle of long action seems to hold true for silicone oil as a tamponade [24, 26], notwithstanding the poorer visual outcomes [23, 32]. The effect of tamponade is thought to rely on contact between the tamponade agent and the reparative glial cells (thus 'isolating' the macula from vitreous cavity fluid). This is achieved by allowing maximal contact between the tamponade and the macula. Even though Foster and Chou [31] described the concept of a 'tolerance angle' within which enough of a break would be covered for surface tension to have its effect on closure, 'maximal coverage' may play a pivotal role in healing. They suggest that patients should be orientated such that the centre of a retinal break is at the highest point with respect to gravity for a tamponade agent to exert its maximal effect. This is true whether the mechanism of the tamponade effect is by buoyancy [30, 33, 34] or surface tension [31]. For a macular hole, this would require face-down positioning.

Disadvantages of FDP

Posturing in the face-down position is difficult for patients. They are usually required to posture face down for between 45 and 55 min of every hour [35]. The total duration of posturing has been debated by many authors. Optical coherence tomography (OCT) studies have shown that flattening of retinal cysts and approximation of macular dehiscence can occur in macular holes of a size of less than 400 μm by the first day postoperatively [36, 37]. Muquit et al. [38] have recently shown sufficient gas-macula contact on Fourier domain OCT 1 day after surgery in the upright position. Eckardt et al. [39] analysed 33 consecutive cases which included 9 stage IV holes. These cases did not undergo ILM peeling and were tamponaded with air. Their FDP was determined by close OCT monitoring. The authors were able to stop FDP after 24 h in 54% of their cases as the holes were closed; 90% of their cases had OCT-proven closed macular holes after 3 days. The same group has recently shown that 79% of macular holes in a larger cohort of 112 patients with air tamponade closed within 3 days [40]. The authors questioned the need for lengthy periods of FDP. Krohn [41] showed no significant visual or anatomical differences between 7 and 3 days of posturing. However, there seems to be no pattern in patients who failed to have their macular holes closed after shortened periods, thus making it difficult to predict those who may need longer FDP.

Patients may be reluctant to endure FDP [42]. Shoulder and neck discomfort, and the psychological morbidity re-

sulting from isolation and boredom secondary to FDP, may prevent patients from complying with FDP. It may even deter them from having macular hole surgery in the first place [43]. One paper suggested that 54% of patients found FDP for 5 days difficult [44].

Waterman et al. [45] suggest that significant training is required to improve nursing input into FDP, and thus patient compliance. Unsurprisingly, patients prefer not to undergo FDP [46]. Furthermore, compliance with FDP is poor [47]. Verma et al. [47] designed a device to digitally record the head position, and applied this to patients after macular hole surgery. Although not detailed, the 10 patients in this study had to follow a 'strict head down posturing regime'. This small group maintained their head posture as instructed for only 38% of the time. This suggests that even when patients are instructed to maintain strict FDP, this is rarely achieved in practice.

FDP is not free of complications. It may interfere with postoperative topical medication administration, which may affect the final closure rate [48]. FDP has been associated with acute angle-closure glaucoma in the fellow eye. [49] Excessive posturing may lead to complications such as ulnar nerve palsies [50] and pressure sores [51]. It is against the backdrop of these controversies that the requirement for FDP has been questioned.

Publications Analysing FDP

Although the evidence for FDP is conflicting, there is widespread agreement that ILM peeling promotes hole closure based on both non-randomised [14, 15, 52] and randomised trials [17, 18]. It may be particularly important in larger macular holes [53]. We have divided comparative studies of FDP into those that incorporated ILM peeling and those that did not.

Because closure of the hole may occur within a few days of surgery, there is uncertainty regarding the duration of any FDP. A few authors compared differing lengths of FDP. It should be noted that in the context of high anatomical success rates, the case numbers of studies are relatively small.

Studies Analysing Shortened FDP with ILM Peeling

Dhawahir-Scala et al. [54] reported a small non-randomised observational trial comparing 20 patients who were advised to posture face down for 24 h only with 8 patients who were advised to maintain FDP for 10 days after phacovitrectomy with ILM peeling. The patients were reviewed finally at 6 weeks. The macular hole closure rates were 20 (100%) of the non-postured group compared with 7 (87.5%) of the postured group. Postoperative logMAR (logarithm of the minimum angle of resolution) visual acuity was 0.42 ± 0.19 for macular holes of <12 months duration, and 0.65 ± 0.16 for >12 months duration. This compared with 0.41 ± 0.28 (<12 months) and 0.65 ± 0.16 in the postured groups. Patients were examined 1 day postoperatively, and if the gas fill was above the inferior arcade, they were asked to undergo FDP. This poor fill may have compromised the closure rate in these patients. However, this does perhaps illustrate the beneficial effect of FDP in eyes with a poor gas fill.

Studies Analysing Shortened FDP without ILM Peeling

Krohn [41] analysed 29 patients who were advised to keep FDP for 7 days compared with 24 patients who were advised to keep FDP for 3 days. No patients underwent ILM peeling. Twenty-one (93.1%) of the 7-day cohort had closed macular holes after 6 months of follow-up compared with 21 (87.5%) of the 3-day group. His cohort comprised mostly stage III holes, with 9 stage IV holes. Krohn suggests that 3 days of FDP may be sufficient.

Isomae et al. [55] compared 34 eyes of 33 patients who were instructed to maintain FDP for 1 week with 21 eyes of 21 patients who were advised to maintain FDP for 24 h. No patients had ILM peeling. The authors reported hole closure in 31 (91.2%) of the 1-week cohort compared with 19 (90.5%) of the 24-hour cohort. One of the limitations of this study was that the two groups were not concurrent. There was also a greater proportion of stage IV holes in the 1-week group.

Studies Analysing No FDP with ILM Peeling

Tornambe et al. [6] published the first report on macular hole surgery without FDP. They analysed 33 consecutive cases who, if phakic, underwent combined cataract extraction, intraocular lens insertion and macular hole surgery (including epiretinal membrane peeling and, if possible, ILM 'scratching'). They reported a closure rate of 79% after 1 surgery, and of 85% after 2 surgeries. They had a heterogeneous consecutive group of patients, with 88% of the holes being graded as stage III or IV and 21% of the holes being present for over 1 year. The authors were the first group to suggest that FDP may be eliminated with combined phacovitrectomy and complete fill of the posterior cavity with C_3F_8 since there have been numerous reports of successful outcomes with limited or no FDP [56, 57], but few comparative trials.

Table 1. Studies with a control arm (FDP) compared with no FDP after macular hole surgery

First author	Date of publi-cation	FDP controls	Number in each arm	Grade/size of holes	Combined cataract surgery	Tamponade	ILM/ERM peeling	Adjuvant therapy	Findings
Simcock	2001 [58]	Historical	20 non-FDP cases vs. 13 FDP controls	13 stage II; 7 stage III; similar % in controls	Yes	C_2F_6 (80% fill)	ILM	No	18 out of 20 (90%) closure rate in non-FDP group (11/13, 85%, in controls); 19/20 (95%) improved VA by 0.3 logMAR in non-FDP group (69% in controls)
Tranos	2007 [59]	Each arm allocated at the different study sites	16 non-posture vs. 25 FDP	85% grade II/III; 15% grade IV	No	C_3F_8	ILM (dye assisted)	No	14/16 (87.5%) anatomical closure in non-FDP group (22/25, 88%, in FDP controls); increased cataract rate in non-FDP group
Guillaubey	2008 [60]	Randomised	72 seated vs. 78 FDP	53% >400 μm	Mixed: yes (41%) no (59%)	Depending on size of MH; SF_6 (20%): <500 μm; C_2F_6 (17%): 500–800 μm; C_3F_8 (14%): 800–1,000 μm	ILM (no dye)	No	31/39 (79.5%) anatomical closure with MH >400 μm in non-FDP group (39/41, 95.1%, in FDP group; p = 0.045[1])
Tadayoni	2011 [62]	Randomised	35 no FDP vs. 34 FDP	<400 μm	5 patients: combined surgery	C_2F_6 (17%)	No	No	32/35 (91.4%) hole closure in non-FDP group (32/34, 94.1%, in FDP group)

MH = Macular hole; VA = visual acuity.
[1] Interpreted as statistically significant.

Simcock and Scalia [58] subsequently published the first comparative study. Their patients underwent combined phacovitrectomy with ILM peeling and were advised to not lie face-up for 10 days. These patients were compared with a historical control group. The rationale for combined surgery includes an improved view of the retina, larger gas fill at the end of surgery, and avoidance of a second operation when cataract develops. Eighteen out of the 20 non-postured eyes (90%) showed macular hole closure after 6 months compared with 11 out of 13 (85%) in the postured group (no significant difference). Nineteen of the 20 eyes (90%) showed an improvement of at least 0.3 logMAR units in the non-postured group compared with 9 of 13 eyes (69%) in the postured control group. The acknowledged limitations include the small number of patients, historical control group, lack of masking and lack of stage IV hole representation.

Tranos et al. [59] published the first prospectively controlled study comparing a postoperative 'no supine position' regime (similarly to Simcock and Scalia [58]) with a 10-day FDP regime. They compared 16 non-postured with 25 FDP patients. Their cohort comprised mostly stage II and III holes, with only 6 patients with stage IV holes. All their cases underwent trypan blue-assisted ILM peeling. They found no significant difference in visual outcomes or primary anatomical closure between the postured (22/25; 88%) and non-postured (14/16; 87.5%) groups. The only difference found was a significantly greater proportion of patients with posterior capsular cataract in the non-postured group 4 months postoperatively, and the authors suggested that phacovitrectomy be considered in non-postured macular hole surgery.

Guillaubey et al. [60] published the first multicentre randomised controlled trial. They analysed 150 eyes of 144 patients who were allocated to no FDP or 5 days of 8 h a day of FDP. All their patients underwent ILM peeling without staining. The study contains a rather heterogeneous group of patients and techniques; 62 patients underwent combined phacovitrectomy, whilst the rest did not. Different gas tamponades were used depending upon the size of the macular hole. SF_6 was used in patients with

holes of <500 μm, C_2F_6 for holes of >500 μm, and C_3F_8 for holes of >800 μm. Notwithstanding these limitations, the authors found that patients with macular holes of >400 μm had worse anatomical outcomes if they did not undergo FDP. Thirty-nine of 41 (95.1%) had anatomical closure 6 months postoperatively in the postured group compared with 31/39 (79.5%) in the non-postured group. They advised that although FDP may not be necessary for small macular holes, they would still recommend it for macular holes >400 μm in diameter.

In 2010, an attempt was undertaken at a meta-analysis of the comparative trials available [61]. With such heterogeneity of preoperative features, definitions of outcome, surgical techniques and follow-up periods, this was difficult. The conclusion of the analysis was that there seemed to be slightly increased macular hole closure rates with 5–10 days of FDP compared with posturing for 24 h or less, but that the difference was not statistically significant.

Studies Analysing No FDP without ILM Peeling

The most recent comparative trial was a randomised controlled parallel-assignment multicentre study [62]. This group of researchers included only macular holes of <400 μm diameter. Patients all underwent peeling of the epiretinal membrane, if present, but no staining or ILM peeling. They then had 17% C_2F_6 injection. Thirty-four patients were randomised to 10 days of FDP, whilst 35 were randomised to avoidance of supine positioning only for 10 days. The authors reported closure after 1 operation in 32 out of 34 (94.1%) in the FDP group compared with 32 out of 35 (91.4%) in the no-posturing group. The mean gain in visual acuity was 10.52 Early Treatment Diabetic Retinopathy Study letters in the FDP group and 10.23 in the alleviated group. The authors suggest that for small holes neither FDP nor peeling of the ILM are essential. Table 1 contains a summary of all comparative trials comparing no posturing with FDP.

Conclusions

The controversy over the importance of FDP after macular hole surgery continues. Studies are very heterogeneous, which makes comparison difficult. The various combinations of combined or separate cataract surgery, ILM peeling or no ILM peeling as well as different tamponade agents make it difficult to study individual risk factors in isolation. No studies have shown 100% closure, and a fuller understanding of the factors that influence outcome might enable surgeons to offer an individualised service based on the risk profile of each patient. The greatest risk factor for anatomical failure seems to be preoperative macular hole size [63]. At present, for small macular holes (<400 μm), a streamlined service with minimal or no FDP may be acceptable. However, for larger holes, FDP appears to have a role [64]. The greatest obstacle to determining conclusively what the benefit of FDP is lies in the high success rate of macular hole surgery. With current closure rates of around 90%, a study designed to look at differences in outcome needs to include very large case numbers. This is compounded by the need to stratify each arm according to hole size and combined or sequential cataract surgery. It may be beneficial to concentrate on larger macular holes, where a lower success rate may make a study more feasible. Even this would have to involve many centres working in collaboration over an extended period of time, and the costs of such an undertaking mean it is unlikely that we will have a definitive answer soon, so the controversy looks set to continue until sufficiently large and well-designed trials can be completed.

Disclosure Statement

The authors have no conflict of interest with the presented material.

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