6. Materials for Scleral Buckling

In 1937, Jess performed what may be considered the first scleral buckling by using a gauze pad to temporarily indent the eye wall for approximating the retinal layer with the choroid [37]. The implant was removed after a few weeks and no ocular tissue reactions were reported. Since then, several materials and design styles have been proposed for manufacturing scleral implants. Basically, scleral buckles may be categorized in two classes: (i) permanent implants and (ii) absorbable devices. Materials tested over the years for manufacturing buckles are listed in Table 2 and Table 3. At present, only silicone implants are commercialized and routinely used in clinical practice, and all other non-absorbable devices have progressively fallen into disuse.

Degradable implants in general carry a higher number of problems and less advantages in comparison with permanent ones, and until now all have only been tested experimentally.

6.1. Permanent Buckles

6.1.1. Implants Fallen in Disuse: Historical Overview

Table 2 qualitatively summarizes the complications encountered using different buckling materials proposed in the literature over the years, but have fallen into disuse; silicone is not included here as it will be treated separately in the next section.

Almost 20 years after the procedure reported by Jess [37], Custodis tested a polyviol band as a scleral buckling element [38,39]. After compression over sclera, the implant could expand *in situ* postoperatively, thereby allowing the closure of retinal breaks and the retina reattachment. However, polyviol elicited serious adverse reactions in the ocular tissues was thus not considered suitable for clinical use.

Table 2. Scleral buckling materials having progressively fallen into disuse (chronological order).

Material	**Long-term Complications** [a]							**References** [b]
	Scleral Erosion	IOP Increase	Adverse Tissue Response	Friability	Migration, Extrusion	Foreign Body Sensation	Persistent Pain	
Polyviol		+++	+++					[38,39]
Polyethylene	+++	+++						[40–42]
Nylon threads	+++		+					[44,45]
Solid PTFE	++	++	+					[46–48]
Polyester	++		+					[49,50]
Hydrogels				+++	+	+	+	[51–59]
Porous PTFE	+	+	++			+	+	[60–64]
PTFE-coated silicone	+	+	++			+	+	[65–67]

[a] Legend: '+' = rare/negligible problem; '++' = occasional/mild problem; '+++' = serious problem.
[b] Citation numbers are referred to in the main text.

In response to the failure of polyviol, in the mid 1950s Schepens proposed polyethylene (PE) tubes as encircling scleral elements: PE could be easily manufactured to produce buckles of different diameters, that could easily be tensioned *in situ* by means of a suture placed in the tubing lumen [40,41]. However, Regan reported that the hardness and rigidity of PE tubes exerted too severe a pressure on the ocular globe and, furthermore, the narrow bearing surface of tubes eventually caused erosion of the underlying sclera and choroid [42].

In order to overcome the drawbacks related to PE tubes, in the late 1950s the use of silicone elements was proposed for the first time by Girard *et al.* [43]; this material remains the best choice today and is described in the next section.

As an alternative to PE, in 1958 nylon braided threads were also proposed for scleral buckling [44]: they were not properly used as a "buckle" but rather for suturing the wall of the eye to create a "fold" which then created a buckling effect. This solution was soon abandoned due to scleral inflammation and erosion [44,45].

Solid polytetrafluoroethylene (PTFE) was tested in the mid 1960s by Wolter *et al.* [46,47], but Deodati *et al.* showed that Teflon implants exhibited similar complications to those encountered with PE tubes [48]. Analogous problems were also encountered by using polyester bands as cerclage elements in the early 1970s [49,50].

A particular mention should be made to hydrogel implants, as they were considered superior to silicone implants for almost 20 years (from their introduction in the mid 1970s to their progressive abandonment in the 1990s), especially as they were softer and seemed to carry a lower risk of infection (less than 1% *vs.* 2–5%) [51,52]. Specifically, three types of hydrogels, *i.e.*, poly(glyceryl methacrylate) (PGMA), poly(2-hydroxyethyl acrylate) (PHEA), and poly[methyl acrylate-*co*-(2-hydroxyethyl acrylate)] (MAI), have been widely investigated [53]. Major advantages of hydrogels are softness, defined swelling under hydration and the potential to act as devices for the controlled release of hydrophilic drugs [54], which is an advantage over solid silicone implants in controlling infection. PGMA was found to suffer from lack of tensile strength when swollen, whereas PHEA exhibits a dramatic tendency to fragment after swelling [55]. MAI, which is commercially sold as Miragel, offers better bulk features and can promote the formation of a strong surrounding capsule [53,54]. Although Miragel has been considered by many surgeons as the ideal solution for scleral buckling, fragmentation of such implants can occur after 10-year follow-up [55–58], as well as buckle overexpansion [56,59], with an associated risk of severe long-term complications (persistent pain, foreign body sensation) and the need of re-operation for implant removal.

Porous expanded PTFE (e-PTFE) was proposed in the form of buckling bands [60–64] or, more recently, as coating on silicone implants [65–67] with variable and controversial outcomes. Potentially, the material could be an alternative to silicone, but further studies of its performances and effects *in vivo* are necessary.

For the purpose of completeness, it is interesting to mention an approach attempted in 1977 by Gloor, who used a silver clasp as an episcleral buckle [68]. The implant was removed after six months due to the pain experienced by patients and to avoid severe eyeball deformations. It should be underlined that, apart from the cotton gauze used by Jess in 1937, this is the only other case involving the use of non-polymeric materials for scleral buckling.