Prosthesis motility with and without intraorbital implants in the anophthalmic socket

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Abstract

Ocular prosthesis motility was measured and compared in 15 patients with a primary baseball implant after enucleation of an eye, in 11 patients with a secondary baseball implant, in 12 patients with an Allen implant, and in 11 patients without any intraorbital implant. In all patients a noticeable lag of movement of the prosthetic eye was measured: in the extreme directions of gaze the excursions of the prosthesis were far less in comparison with the contralateral normal eye. For normal eye movement round the primary position of gaze, however, the prosthesis motility in the primary baseball and Allen implant group appeared to be sufficient to give a lifelike appearance. The average motility of the prostheses in these two groups did not differ. The motility in the secondary baseball group and in the group without an implant was evidently worse. In the last group the prosthesis motility was most impaired. We conclude that the insertion of an implant, even when inserted some time after the enucleation (a secondary implant), improves the motility of the prosthesis markedly. We recommend the primary baseball implant as the correction of choice after enucleation.

The cosmetic disfigurements which arise after enucleation of an eye include enophthalmos, retraction of the upper eyelid, deepening of the superior sulcus, backward tilt of the prosthesis, and stretching of the lower eyelid.¹ These symptoms, summarised in 'the postenucleation socket syndrome,' may arise separately or in combination and vary in severity. To regain a normal appearance after the enucleation they should be prevented and/or treated. This is best accomplished by substitution of the orbital volume loss (6-7 ml) with an adequate intra-orbital implant.

Motility of the artificial eye is another important factor which contributes to the normal appearance of the anophthalmic orbit. Because a certain amount of prosthesis motility is a prerequisite for a lifelike aspect of the anophthalmic socket, we studied the motility in a series of patients consulting the ocularist at the Orbital Centre. This series comprises 15 patients with a primary and 11 patients with a secondary baseball implant, 12 patients with an Allen implant, and 11 patients without an implant. The prosthesis motility in these patients was measured and compared.

Patients and methods

In a group of 49 consecutive patients who visited

the ocularist (EG) after enucleation of an eye for various reasons the motility of the ocular prosthesis was evaluated. All the patients had an optimal fitting prosthesis from the ocularist's point of view. Fifteen patients had a primary baseball implant, 11 a secondary baseball implant, 12 an Allen implant, and 11 patients had no intra-orbital implant. The baseball implants² were 18 mm acrylic balls covered with donor sclera. They were all inserted in our centre according to the primary and secondary implantation technique as described by Collin.³ In the case of primary implantations the ball covered by sclera was placed in Tenon's space. The four rectus muscles were attached to the sclera with double armed sutures. Tenon's capsule and the conjunctiva were closed in two layers. For the secondary implantation technique the sclera covered ball was inserted into the intraconal fat, posterior to Tenon's capsule. Before implantation three double armed sutures were attached to the sclera at the 3, 6, and 9 o'clock positions. They were passed medially, laterally, and inferiorly through Tenon's capsule and the conjunctiva after insertion of the ball. The Allen implants,⁴ with short tunnels through which the rectus muscles are drawn and sutured to each other, had all been inserted elsewhere.

The reasons for enucleation and the clinical characteristics in the four subgroups are summarised in Table 1. Patients who had sustained severe orbital trauma were excluded from this study.

The motility of the prosthesis and of the contralateral normal eye was measured with the Kestenbaum's limbus test.^{5,6} The patients were provided with spectacles with frontoparallel acrylic glasses divided by a metric scale. For accurate motility readings pictures were taken of all patients wearing the Kestenbaum spectacles. During photography equal illumination by indirect lighting was achieved by placing the patient's head in a half globe with a white inner surface with two partly screened flash lights. The camera was placed on a stand in front (Fig 1). Pictures were taken with the patient looking straight forward and in three directions of gaze: abduction, adduction, and elevation (Fig 2). Depression was not measured because the upper eyelid covers the eye when looking downward. A water scale connected with the millimetre graduated glasses prevented false horizontal readings during photography. To enlarge the slides, they were projected on a screen to facilitate motility reading. Motility readings were performed with the temporal limbus as a landmark for adduction and the nasal limbus as a landmark for abduction. The inferior pupillary border was used as a landmark for measuring elevation. The position of these landmarks in the primary

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Table 1 Patient characteristics

	Primary baseball implant (n=15)	Allen implant (n=12)	Secondary baseball implant (n=11)	No implant (n=11)
Reason for enucleation:				
Ocular trauma	3	1	7	6
Painful blind eye	5	6	1	3
Melanoma	7	5	2	1
Unknown tumour	—	—	1	1
Age at enucleation (years)	47.9 (17–80)	50.6 (37–65)	22.8 (6–48)	28.7 (7–63)
Age at implantation (years)	47.9 (17–80)	50.6 (37–65)	40.3 (21–67)	—
Time interval between enucleation and investigation (years)	1.9	2.2	19.4	18.9
Prosthesis weight (g)	1.9, SD 0.6	2.0, SD 0.6	1.5, SD 0.5	3.0, SD 1.1

position of gaze (when looking straight forward) was used as point of reference. In this way excursions of 0.5 mm or more could be determined. The mean motility in abduction, adduction, and elevation and the mean of the excursion in those three directions were calculated for each subgroup.

Values are expressed as mean with standard deviation (SD). Statistical analysis was performed by the two-tailed Mann-Whitney U test for comparisons of means between groups. To calculate the correlation coefficients the non-parametric one-tailed Spearman rank correlation test was used. For all analyses $p < 0.05$ was considered statistically significant.

Results

Table 2 shows the results of our measurements. The motility of the artificial eye was reduced substantially in all patients as compared with the motility of the contralateral eye. A motility loss of 50% or more was found. The mean motility in the primary baseball group averaged 2.3 mm, in the Allen implant group 2.2 mm, in the secondary baseball group 1.7 mm, and in the group without an implant 1.1 mm. The primary baseball and Allen implant patients had the best motility, whereas patients without an implant had the poorest motility. The motility of the artificial eye in the secondary implant group was intermediate. We found no correlation between the motility

Figure 1 Camera set-up for measurement of prosthesis motility.

Figure 2 Patient looking straight forward and in the three directions of gaze.

and the prosthesis weight nor between motility and the age of enucleation, the age at implantation, or the time interval between the date of enucleation and the date of investigation in each subgroup.

Discussion

A noticeable lag of movement of the prosthetic eye was measured in all four subgroups in the extreme directions of gaze. This loss of motion may be explained by orbital changes which follow enucleation, shortcomings in the current prosthesis fitting techniques and/or surgical techniques, fibrosis of the extraocular muscles, and inadequate transmission of movement from the anterior surface of the socket to the posterior surface of the prosthesis. Other authors^{6–8} also measured a poor overall motility of the prosthesis after enucleation.

The Allen implant, a buried quasi-integrated 'motility' implant,⁹ has a flat anterior surface to which the flat posterior surface of the prosthesis is adapted. By this closer coherence the motility of the prosthesis is meant to be enhanced. Despite the design the Allen implant did not show better motility than the primary baseball implant. Apparently, as has been previously suggested,^{7 10 11} the motility of the prosthesis, which rests in the conjunctival sack and is held in place by the lids, is derived from retraction of the fornices by contraction of the different rectus

Table 2 Prosthesis motility

	Primary baseball implant (n=15)	Allen implant (n=12)	Secondary baseball implant (n=11)	No implant (n=11)	Contralateral, normal eye (n=49)
Abduction (mm)	2.2 (0.9)	2.5 (1.1)	1.6 (0.7)	1.3 (0.6)	8.6 (1.9)
Adduction (mm)	2.1 (0.9)	1.6 (0.9)	1.6 (0.8)	1.4 (0.9)	8.0 (1.4)
Elevation (mm)	2.7 (1.6)	2.4 (1.3)	2.0 (1.2)	0.6 (0.7)	5.5 (1.6)
Mean (mm)	2.3 (0.8)	2.2 (0.8)	1.7 (0.6)*	1.1 (0.5)†	7.4 (2.1)

*Significantly different from the values in the primary baseball implant group (U=43).

†Significantly different from the values in the primary baseball implant group (U=16.5), the Allen implant group (U=15), and the secondary baseball implant group (U=21). Standard deviations in parentheses.

muscles with simultaneous relaxation of the opposing muscles, rather than from transmission of movement from the implant to the prosthesis. The Allen implants are prone to tilt in the orbit after implantation; the lower and temporal edges of the anterior surface of the implant mostly protrude, while the upper and nasal edges are tilted backwards. This may explain the difference in maximal excursion of the prosthesis in abduction and adduction in this subgroup (Table 2).

We did not find a relationship between the weight of the prosthesis and the motility in each of the four subgroups. Consequently, we could not confirm the concept¹² that the weight of the artificial eye has an effect on motion because it would take more energy and more friction to set a larger mass in motion. As was to be expected, the weight of the prosthesis in the group without an implant was higher than in the 'implant' subgroups. On average the weight of the prosthesis for the patients with a secondary implant was less than for the patients with other implants. This is explained from the finding in a previous study¹³ that secondary implants generally are situated more anteriorly in the orbit than primary implants.

The implantation of a baseball implant after enucleation is a relatively new technique.² In our centre it was introduced in the early 1980s. From that time onwards (nearly) all patients routinely received a primary baseball implant following enucleation. Consequently, the primary implant group includes patients who were enucleated since the baseball implant was introduced, whereas in the secondary implant group the patients were enucleated before then. This explains the difference in time interval between date of enucleation and investigation in the two subgroups (Table 1).

The primary baseball and Allen implant group comprised relatively more patients who underwent enucleation for malignant melanoma, whereas in the secondary implant group and in the group without an implant relatively more patients were enucleated for ocular trauma. The differences in age at enucleation in the subgroups (Table 1) may be explained by the fact that malignant melanoma is usually seen in later life and ocular trauma in earlier life. The majority of patients who underwent enucleation for ocular trauma did not receive an implant immediately after the enucleation, probably for fear of extrusion.

The prosthesis motility associated with various implants could be compared by the method

used. In contrast to De Voe,¹⁰ who stated that a delayed implant does not improve the movement of the prosthesis, we found that the insertion of an implant, be it primary or secondary, markedly improves the motility. This phenomenon has also been noted by other authors.^{6,12} Because we could not demonstrate a relationship between the weight of the prosthesis and motility, the better prosthesis motility in the implant patients cannot be explained by the decreased weight of the prosthesis required after insertion of an implant. We further concluded that there is no need to prefer an Allen implant to a primary baseball implant for motility reasons. On the other hand, the Allen implant suffers some disadvantages over spherical implants, such as uncomfortable socket, difficulty in prosthesis fitting, insufficient volume substitution, and tilting of the implant with exposure of the sharp edges and high risk of subsequent extrusion.^{14,15} The baseball implant, on the contrary, usually corrects the orbital volume deficit adequately. In contrast to the Allen implant, which can be inserted only at the time of enucleation, the baseball implant can be used as a primary as well as a secondary implant. Furthermore the baseball implant permits additional volume substitution by insertion of a subperiosteal implant when a noticeable volume deficit is still apparent.

The numbers in Table 2 represent the motility in the extreme directions of gaze. In normal contact and in personal interactions, however, these extreme eye excursions are usually not applied. So the loss of motility on the affected side, which we found by measuring in these ranges, is not so dramatic in practice as the values might suggest. Often it was impossible to point out the affected side at first sight, especially in those patients with a primary baseball or an Allen implant, whereas during photography the enucleated side showed itself only when the patient was asked to look in the extreme directions of gaze. Apparently, as other authors^{3,16,17} also noted, adequate motility in small excursions and good 'quick motion' in conversation are more important for preserving a natural appearance.

Better prosthesis motility in extreme eye excursions was linked with better motility in small excursions. So immediate prosthesis movement in small excursions concurrently with the fellow eye was found to be best in the primary baseball and Allen implant group, less in the secondary implant group, and the least in those patients without an implant.

From the foregoing it is clear that the primary baseball implant is preferred after enucleation. This implant restores the patient's physiognomic aspect very well, in both a cosmetic and functional sense.

- 1 Smit TJ, Koornneef L, Zonneveld FW, Groet E, Otto AJ. Computed tomography of the post-enucleation socket syndrome. *Ophthalmology* 1990; **97**: 1347-51.
- 2 Frueh BR, Felker GV. Baseball implant. A method of secondary insertion of an intraorbital implant. *Arch Ophthalmol* 1976; **94**: 429-30.
- 3 Collin JRO. Socket surgery. In: Collin JRO, ed. *A manual of systematic eyelid surgery*. 2nd ed. Edinburgh: Churchill Livingstone, 1989: 121-37.
- 4 Allen JH, Allen L. A buried muscle cone implant. *Arch Ophthalmol* 1950; **43**: 879-90.

- 5 Hasse W. Messung der maximalen Bewegungsstrecken der Bulbi. *Graefes Arch Clin Exp Ophthalmol* 1976; **198**: 291–6.
- 6 Sassmannshausen J, Bornfeld N, Kluge A, Sauerwein W, Harting F, Wessing A. Enucleation combined with orbital implants for malignant melanoma of the uvea. *Int Ophthalmol* 1989; **13**: 243–51.
- 7 Tyers AG, Collin JRO. Baseball orbital implants: a review of 39 patients. *Br J Ophthalmol* 1985; **69**: 438–42.
- 8 Bosniak SL, Nesi F, Smith BC, Schechter B, Cote R. A comparison of motility: autogenous dermis-fat vs synthetic spherical implants. *Ophthalmic Surg* 1989; **20**: 889–981.
- 9 Guyton JS. Symposium: orbital implants after enucleation. Procedures and physiologic factors. *Trans Am Acad Ophthalmol Otolaryngol* 1952; **56**: 21–4.
- 10 DeVoe AG. Experiences with the surgery of the anophthalmic orbit. *Am J Ophthalmol* 1945; **28**: 1346–51.
- 11 Soll DB. The anophthalmic socket. *Ophthalmology* 1982; **89**: 407–23.
- 12 Bartlett RE, Lewis F. Evaluation of enucleations and eviscerations. *Am J Ophthalmol* 1964; **58**: 835–9.
- 13 Smit TJ, Koornneef L, Zonneveld FW, Groet E, Otto AJ. Primary and secondary implants in the anophthalmic orbit: pre- and postoperative computed tomographic appearance. *Ophthalmology* 1991; **98**: 106–10.
- 14 Nunery WR, Hetzler KJ. Improved prosthetic motility following enucleation. *Ophthalmology* 1983; **90**: 1110–15.
- 15 Soll DB. Evolution and current concepts in the treatment of the anophthalmic orbit. In: Smith BC, Della Rocca RC, Nesi FA, Lisman RD, eds. *Ophthalmic plastic and reconstructive surgery*. St Louis: Mosby, 1987; **2**: 1321–8.
- 16 Troutman RC. Five-year survey on use of a magnetic implant for improving cosmetic result of enucleation. *Arch Ophthalmol* 1954; **52**: 58–62.
- 17 Roper-Hall MJ. Orbital implants. *Trans Ophthalmol Soc UK* 1954; **74**: 337–46.