Economic costs of cataract surgery using a rigid and a foldable intraocular lens

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Summary
Optimal delivery of healthcare requires consideration of various costs. A foldable intraocular lens (IOL) is more expensive than an equivalent rigid IOL. However, surgical and post-operative costs may make a foldable IOL economically preferable. We compared the economic costs of cataract surgery plus implantation of a foldable IOL with implantation of a rigid IOL. Prospective audit of the clinical records of 82 pseudophakes; 39 implanted with a rigid IOL and 43 implanted with a foldable IOL by one surgeon. Average follow-up periods were 25 ± 7 months and 23 ± 5 months respectively. There was no difference between the two groups for the follow-up period (P = 0.55), number of post-operative complications (P = 0.25) or cost of post-operative visits (P = 0.83). The cost of single-use theatre equipment was greater for the rigid-IOL group (P = 0.0001). The total identified cost per patient was greater for the foldable-IOL group (P = 0.0001). Despite possible technical advantages, implantation of the foldable IOL did not provide an economic benefit, either in the initial cost or in the costs of post-operative care. Over the 2-year period, implanting with the rigid IOL cost, on average, £57 less per patient. Despite this economic difference, a cost-benefit analysis is required, since other factors may be more important.

Introduction
In recent years the use of cheaper, equivalent medical procedures and medications by the National Health Service (NHS) has been discussed widely in all aspects of health care. Cost-effective use of available resources has become an important role of health care management. Hence, evaluating and reducing the cost of surgery is an important issue. However, there is a delicate balance between using a less expensive procedure and optimising patient care. A less expensive procedure may compromise the welfare of the patient and result in unnecessary related expenditure due to greater post-operative care requirements. The optimal surgical procedure would cost less and cause fewer and lesser post-operative complications (hence lower cost). One method for reducing costs has been the move to outpatient or day-case surgery, thereby decreasing the demand for overnight hospital beds. Phacoemulsification and small-incision surgery have allowed cataract surgery to be conducted, most commonly, on a day-case basis.

The fundamental concern of a cataract surgeon is the restoration of sight. If a patient’s sight is restored to an acceptable level, with few, if any, post-operative complications, then the surgery has been successful. Foldable intraocular lenses (IOLs) have allowed micro-incision surgery, typically involving smaller, self-sealing incisions (no sutures). As foldable IOLs are more expensive on average than rigid IOLs, to be cost-effective, the foldable IOLs must have other advantages. One such advantage could be fewer complications.
post-operative complications. Lower rates with foldable IOL than with rigid IOL implantation of anterior capsule movement (Ursell et al., 1997), adherence of pseudomonas aeruginosa (Gabriel et al., 1998), adherence of inflammatory cells (Hollick et al., 1998, 1999a) and posterior capsular opacification (PCO) (Ursell et al., 1998; Hollick et al., 1999b) have been reported. Another advantage of acrylic IOLs could be visual outcome. There appears to be a small advantage in the visual performance of pseudophakes implanted with foldable acrylic IOLs when compared to rigid PMMA IOLs (Kohnen et al., 1996; Hayashi et al., 1998; Ursell et al., 1998; Afsar et al., 1999; Hollick et al., 1999b). Two of these studies found no difference in vision, but had relatively short follow-up periods (Kohnen et al., 1996; Afsar et al., 1999). One well-reported study found no differences in vision after 2 years (Ursell et al., 1998) and a small, but non-significant, difference after 3 years that was associated with a difference in the rate of PCO (Hollick et al., 1999b). After 2 years, Hayashi et al. (1998) found a difference in visual acuity between PMMA and both acrylic and silicone, that was associated with a difference in the rate of PCO. After 12 years, Khan and Percival (1999) reported a small, but apparently non-significant difference in vision between a PMMA and a poly-HEMA IOL. Another advantage could be induced astigmatism. While there have been numerous reports of post-operative changes in astigmatism, it appears that when the incision is sufficiently small, the length of the incision and the presence of a suture have only a small impact on induced astigmatism (Mendivil, 1996; Zheng et al., 1997; Lyhne et al., 1998; Olson and Crandall, 1998; Afsar et al., 1999). Similarly, for small incisions, changes in astigmatism with time are small (Zheng et al., 1997; Olson and Crandall, 1998). Therefore, it is unlikely that there would be a difference in costs for optical care (e.g. spectacles) attributable to the type of IOL implanted when using small-incision surgery.

Previous investigations into the economic costs associated with cataract surgery have reported issues other than comparisons between IOL types (Filer et al., 1991; Steinberg et al., 1993; Asimakis et al., 1996; Marseille, 1996). In a developing-country context, Marseille (1996) reported that, even considering a worst-case scenario, cataract surgery was one of the most cost-effective of all medical procedures. As IOLs became more frequently used in Britain, Davies et al. (1986) demonstrated that the higher initial cost of an IOL was quickly offset by the cost of continued care, typically in the form of spectacles or contact lenses. Before the advent of foldable IOLs, the main economic issue was the difference between ECCE and phacoemulsification (Asimakis et al., 1996). Asimakis et al. (1996) reported that phacoemulsification cost more than ECCE, but felt that this difference was low (approximately £142). The actual cost difference may have been less than this due to their many assumptions. Despite this extra cost, the benefits of a smaller incision, including less induced astigmatism, have made phacoemulsification more widely used than ECCE (DamJohansen and Olsen, 1993; DamJohansen and Olsen, 1997; Holweger and Marefat, 1997). Similarly, in the management of PCO, laser capsulotomy was found to cost more than surgical capsulotomy (Rich, 1987), but the benefits of fewer complications outweighed the initial cost, making laser capsulotomy the most common treatment method. Day-surgery tends to be cheaper than in-patient cataract surgery (Percival and Setty, 1992) and specialist cataract centres tend to be cheaper than general clinics (Cresswell et al., 1996).

We were not aware of any reported economic evaluations comparing the costs of rigid and foldable IOL implantation and subsequent care. To directly compare the cost-effectiveness of each IOL, we conducted a randomised, prospective study. All patients were operated on by the same surgeon and followed for 2 years after IOL implantation. There are many different foldable IOLs available in a number of different materials (Callahan, 1987; Martin et al., 1993; Aronosa, 1995; Kaoy, 1996; Gabriel et al., 1998), and one of the newest materials available at the commencement of our study in 1995 was Acrysof™ (Alcon, Hertfordshire). This material has some advantages over both silicone and PMMA IOLs. (Dick et al., 1997; Gabriel et al., 1998; Hayashi et al., 1998, 1999b; Hollick et al., 1998, 1999b; Ursell et al., 1998; Newland et al., 1999). We compared identifiable surgical and post-operative costs when implanting with Acrysof™ and PMMA IOLs, made by the one manufacturer. It is important to note that our study compares direct economic costs, therefore is not a cost-benefit analysis (a much more complex undertaking requiring evaluation of factors such as quality of life).

Materials and methods

All patients in this prospective, randomised study received monocular phacoemulsification cataract extraction and IOL implantation by one surgeon (WW) conducted at the Southern General Hospital (SGH), Glasgow. Irrespective of any preoperative astigmatism, the scleral incision was always in the same position; 1–2 mm behind the limbus and centred at approximately 11 o’clock. The scleral incision was either 5.5 or 4.0 mm in length depending on whether the IOL to be implanted was rigid or foldable respectively. The IOL was implanted in the capsular bag of each subject and the incision was either sealed with one 10° nylon cross-over suture or left to self-seal. After 2 years a total of 82 records were available for audit. Of these 43 had been implanted with a foldable, acrylic IOL (model MA60BM), and 39 had been implanted with a rigid, PMMA IOL (model LX10BD). Three patients who passed away during the 2-year audit period were not included.

The SGH administration department provided information about the cost of single-use theatre items and post-operative visits for cataract surgery. Surgeon fees, costs
of theatre equipment, time per operation and the number and cost of theatre staff present during the procedure were not supplied. These costs varied according to a number of different factors unrelated to the type of IOL implantation. In this teaching hospital, operating theatre scheduling was independent of the type of IOL. Thus, these were uniform costs for both IOL types. The SGH did not make any distinction as to the grading of the physician on duty during post-operative episodes (e.g. consultant or senior house officer). Therefore the cost included for a post-operative visit was the average cost, irrespective of the grading of the physician present. Post-operative episode costs included an average for ancillary staff costs (e.g. reception and nursing).

All patients followed a three visit model: day-surgery; followed by one visit one day post-operative; and then one visit 1 month post-operative. If the operated eye had healed and no post-operative complications were noted at the 1-month visit, the patient was discharged from the Out-Patient Department. Other post-operative visits were included only when related to complications in the operated eye. The cost of the single-use theatre equipment for one theatre episode was £81.39 for both groups if no suture was required. Other identifiable costs were: (1) a suture pack at £6.25; (2) a foldable IOL at £79.00; (3) a rigid IOL at £30.00; (4) a post-operative episode at £80.00; and (5) laser capsulotomy at £120.00 per episode. All patients in the rigid-IOL group received one suture at £120.00 per episode. The cost of theatre scheduling was independent of the type of IOL.

The overall economic cost difference between the two IOL types depended on the differences between the cost of the two IOLs and whether a suture was used, not on the costs of the operating theatre, single-use theatre items or post-operative visits. Since our study is the first to report the difference in cost between rigid and foldable IOL implantation, we cannot compare directly our results with previous reports. The rate of performance of cataract surgical costs for the rigid-IOL group greater (Mann-Whitney, \( Z = -8.0, P = 0.001 \)). However, including the cost of the IOL made the foldable-IOL group costs greater on completion of the surgical procedure (Mann-Whitney, \( Z = -8.0, P = 0.001 \)).

The average follow-up periods of 25 ± 7 (range 15–39) months and 23 ± 5 (range 15–39) months for the rigid-IOL and foldable-IOL groups respectively were not significant different (Mann-Whitney, \( Z = -0.60, P = 0.55 \)). Different types of post-operative complications (Table 1) were found for the two groups, but the number of follow-up visits was not significantly different (Mann-Whitney, \( Z = -0.21, P = 0.83 \)).

One patient with a rigid IOL required laser capsulotomy, but this was considered to be unrelated to the IOL. Only two patients with a foldable IOL required laser capsulotomy, one of whom had PCO prior to IOL implantation. Therefore, only one person developed PCO post-operatively in the foldable-IOL group (2.3%). The one patient who had post-operative PCO had laser capsulotomy and then presented with regrowth of lens matter across the back of the IOL that was treated again. There seemed no medical explanation for this regrowth of lens matter. Overall, there was no statistically significant difference in the number of post-operative complications between the two groups (Chi-square test, \( X^2 = 0.03, P = 0.25 \)). Although different complications cause different levels of disability to the patient, such differences were not taken into consideration. Each complication was considered equivalent since the cost of a post-operative episode was the same irrespective of the degree of disability caused. The small difference in average post-operative cost per patient—£176 (median £160, range £160–£321) for the rigid-IOL group versus £182 (median £160, range £160–£400) for the foldable-IOL group—was not statistically significant (Mann-Whitney, \( Z = -0.20, P = 0.84 \)).

Combining all definable costs, the average total identified cost per patient was £297 (median £278, range £272–£439) for the rigid-IOL group and £354 (median £327, range £321–£701) for the foldable-IOL group. As the foldable-IOL group had a higher cost per patient (Mann-Whitney U, \( Z = -5.9, P = 0.0001 \)), implanting a patient with the foldable acrylic IOL cost the NHS approximately £57 on average more than implanting a patient with the rigid PMMA IOL over the audit period.

Table 1. Post-operative complications found in the two groups of pseudophakes

<table>
<thead>
<tr>
<th>Complication</th>
<th>Foldable IOL</th>
<th>Rigid IOL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dendritic ulcer</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Dry eye</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>High intraocular pressure</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Post-operative PCO</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Blepharitis</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Corneal abrasion</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>Inflammation</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Haemorrhage</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Cystoid macular oedema</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>Total</td>
<td>6</td>
<td>5</td>
</tr>
</tbody>
</table>

Discussion

The overall economic cost difference between the two IOL types depended on the differences between the cost of the two IOLs and whether a suture was used, not on the costs of the operating theatre, single-use theatre items or post-operative visits. Since our study is the first to report the difference in cost between rigid and foldable IOL implantation, we cannot compare directly our results with previous reports. The rate of performance of cataract
surgery procedures (Steinberg et al., 1993) and the preference of the surgeon for a specific technique or equipment (Filer et al., 1991) have been reported as major cost factors in cataract surgery. As one surgeon conducted all surgery in our study, surgical experience and choice was not a factor. In the only study of the cost of single-use theatre items, Filer et al. (1991) reported that core equipment costs were £88 for a cataract surgery procedure with additional costs according to surgeon preference. The same amount as our figure of £88 when the cost of nylon sutures was included.

Steinberg et al. (1993), in a large retrospective study, found that the frequency of laser capsulotomy was a major cost of cataract surgery. In our study the small number of patients who developed PCO that required laser capsulotomy, made this a relatively small contributory cost. Often more expensive procedures have been adopted due to advantages unrelated to cost (Rich, 1987; DamJohansen and Olsen, 1993; Steinberg et al., 1993; Asimakis et al., 1996; DamJohansen and Olsen, 1997; Holweger and Marefat, 1997) or longer-term cost advantages (Davies et al., 1986). Similarly, despite a higher initial cost, foldable acrylic IOLs would cost less if the expected lower post-operative complication rates (Ursell et al., 1997; Gabriel et al., 1998; Hayashi et al., 1998; Ursell et al., 1998; Hollick et al., 1999b) had been found. The incidence of PCO in our study was lower than reported by other investigators (Oshika et al., 1996; Hayashi et al., 1998; Schaumberg et al., 1998; Ursell et al., 1998; Hollick et al., 1999b) and lower than the 11% found as a whole at Southern General Hospital. With 82 patients included in our audit, there was adequate statistical power ($a = 0.05; \beta < 0.08$) to find a difference in the rate of laser capsulotomy of the size reported previously (Hayashi et al., 1998; Hollick et al., 1999b). It is unlikely that our surgeon had a technique that somehow avoided PCO more than other surgeons. Though the same acrylic IOL was used (MA60BM), there was a difference between the PMMA IOLs our study (LX10BD) and those used in the other studies (MZ60BD (Hayashi et al., 1998) and MC60BM (Ursell et al., 1998; Hollick et al., 1999b)). Perhaps there was a difference in the PMMA. The most likely cause for the apparent discrepancy in PCO incidence is the classification criteria. Whereas both Hayashi et al. (1998) and Ursell and colleagues (Ursell et al., 1998; Hollick et al., 1999b) used sophisticated examination techniques, in our study all diagnoses were made in a general ophthalmology clinic. Hence, we suspect that only clinically significant PCO was recorded. The clinically determined need for laser capsulotomy may have been a major determinant of a recorded diagnosis of PCO. This classification was appropriate in our study, since it identified actual costs incurred in a typical clinic. Possibly there were differences in the amount of change required before capsulotomy was conducted. In addition, in our study patients were not recalled for planned visits after the initial three visits, unlike the studies that have reported differences in PCO incidence between IOL types. Thus it is possible that PCO incidence may have been higher among our patients than reported here, with patients returning for a post-operative visit only when vision was seriously compromised. To examine this possibility, following completion of the audit we reviewed most of the patients in the rigid-IOL group and found one new case of PCO. That individual had made an appointment for a time after completion of our audit. In a systematic review, Schaumberg et al. (1998) found large differences in PCO rates, but were unable to identify specific causes for those differences. As noted earlier, post-operative benefits of lower rates of anterior capsule movement (Ursell et al., 1997), adherence of pseudomonas aeruginosa (Gabriel et al., 1998) and adherence of inflammatory cells (Hollick et al., 1998) have been reported for acrylic IOLs. While these benefits were not apparent in our analysis of economic costs, such factors must be considered in a cost-benefit analysis.

It is possible that there were economic costs associated with the cataract surgery that we did not identify. A difference in the cost of optical care (e.g. spectacles) is unlikely. We reported previously (Afser et al., 1999) that there was no difference in induced astigmatism between these two groups and a control group two months after surgery, unlike a similar study that made limbal incisions (Olson and Crandall, 1998). Zheng et al. (1997) reported that incisions 6 mm or less, that were about 1.5 mm behind the limbus, produced little induced astigmatism, and that astigmatism was quite stable over a 3-year period. Even if induced astigmatism were different between the IOL types, the relative cost difference for spectacles would be insignificant as the prices for the type of spectacle lenses required by IOL patients do not vary with astigmatism, until the astigmatism is marked.

In addition to the lack of a benefit in reduced post-operative complications or costs, previously this foldable acrylic IOL has been shown to provide no benefit in vision or residual astigmatism (Kohnen et al., 1996; Ursell et al., 1998; Afser et al., 1999; Hollick et al., 1999), except in the presence of PCO (Hayashi et al., 1998; Hollick et al., 1999b). Over the 2 year period of our study, use of the foldable IOL cost £57 more per patient than use of an equivalent rigid IOL. Our results are the absolute differences and not relative costs since the full costs per procedure were not known. Irrespective of the absolute versus relative costs argument, if our results were similar to the national experience, a saving of £57 per patient would have amounted to a substantial saving that could have been deployed elsewhere in the hospital and the NHS. However, given the considerable differences between surgeons, centres and countries (Schein et al., 1995; Norregaard et al., 1997, it is unlikely that this figure can be translated directly into a typical cost saving. Comparison of the cost-benefit of the cheaper rigid-PMMA procedure that may have
a higher complication rate (though we did not find one) against the more expensive foldable-acrylic procedure was beyond the scope of this study.

In our study, the primary cost difference over the two years was the difference in cost between the two IOLs. In some settings it may be possible to reduce the higher initial cost of a foldable IOL, though in our experience, the cost differential between rigid and foldable IOLs remains, even with volume discounts. Such price discounts are not available in low volume settings. Reducing the time taken in the operating theatre for foldable-IOL implantations could offset the higher cost of the foldable IOL. Reduced operating time may be possible with even smaller incisions (3 mm or less is not uncommon now) given sufficient surgeon skill in placement of the foldable IOL. Foldable IOLs allow a sutureless corneal wound, thus reducing surgical time. In our experience, this is only about 1–2 min. as additional time is spent manipulating the foldable IOL. Sutureless incisions allow a quieter eye post-operatively. Since most patients required only two post-operative visits, this did not provide an economic benefit in our study, but may have had qualitative benefits for most patients. Also, foldable IOLs provide a larger optic—a benefit relevant for diabetic patients and other patients for whom fundus examination or treatment may be necessary—whilst retaining the benefits of a small wound. In the final analysis, one has to weigh the advantages of a larger optic IOL and a self-sealing micro-incision against a lower cost, smaller optic IOL requiring a small, sutured incision. Such cost-benefit analyses are likely to differ between settings and to change as new information becomes available.

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References


