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Original Article

Time Trade-off Utility Analysis for Surgical Intervention in Comitant Strabismus, Glaucoma, and Cataract

Fumiko Kishimoto[a,b]*, Tomoko Naito[a], Satoshi Hasebe[a], and Hiroshi Ohtsuki[a]

[a]*Department of Ophthalmology, Okayama University Graduate School of Medicine, Dentistry and Pharmaceutical Sciences, Okayama 700-8558, Japan, and* [b] *Division of Ophthalmology, Ibara Municipal Hospital, Ibara, Okayama 715-0019, Japan*

The utility value was compared among 3 surgical interventions, and the validity of the time trade-off (TTO) method was evaluated by analyzing the correlations of the utility value with the results of the Visual Function Questionnaire-14 (VF-14) and other variables. The subjects were 127 patients aged 40-85 years who were surgically treated between January 2008 and March 2010, including 26 patients with glaucoma, 50 with cataracts, and 51 with comitant strabismus. The scores on VF-14 and utility values determined using TTO were calculated retrospectively. The mean value (SD) of the utility gain was 0.096 (0.105) for glaucoma, 0.101 (0.105) for comitant strabismus, and 0.167 (0.237) for unilateral and 0.245 (0.167) for bilateral cataracts, indicating significant postoperative improvements in the utility value. A significant correlation was observed between the utility value and the postoperative VF-14 scores of the bilateral cataracts, and the postoperative visual acuity of the better eye of the unilateral cataract. The mean value of the quality-adjusted life years was 2.181 for bilateral and 1.424 for unilateral cataracts, 1.132 for strabismus, and 0.870 for glaucoma with an annual discount rate of 3%. The gain of utility value was highest in bilateral cataracts, and lowest in glaucoma, and thus the TTO analysis was considered to be highly valid for cataract surgery.

Key words: surgical intervention, VF-14, utility analysis, time trade-off, quality-adjusted life years

Utility analysis is a generic instrument, applicable across interventions in all specialties, which quantifies the QOL associated with a health state [1]. The utility value used in utility analysis is an index of the severity of diseases defined on a continuous scale from 0 to 1, where 0 corresponds to the worst possible QOL weight, equal to death, and 1 corresponds to the best possible QOL weight, equal to perfect health. There are 4 basic variants of utility analysis, time trade-off (TTO), standard gamble, willingness to pay, and multi-attribute. Of these, TTO utility analysis is the most appropriate and is an instrument that is understood by the majority of patients [2-6] and shows good reproducibility [7-10]. The validity of the TTO analysis is demonstrated by the fact that when visual acuity in the better-seeing eye decreases, the TTO utility decreases correspondingly [9, 11].

Using the utility value, the quality-adjusted life years (QALYs) can be calculated [2, 12]. QALYs are calculated by multiplying the measured mean utility gain by the measured mean life expectancy, and can be used as a unit for evaluating the effect of medical intervention. By dividing the actual medical expenditure by the QALYs, the efficiency of medical inter-

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*Corresponding author. Phone:+81-866-62-1133; Fax:+81-866-62-1275
E-mail:fumiko-k@mvf.biglobe.ne.jp (F. Kishimoto)

vention, *i.e.*, cost-effectiveness, can be calculated. To more efficiently use the limited medical resources available today, analysis of the cost-effectiveness of various medical interventions is considered important in devising health care policies [12]. Reports [13] summarizing the cost-effectiveness in the field of ophthalmology published to date include those dealing with premature retinopathy, macular edema associated with retinal vein branch occlusion, laser therapy for choroidal neovascular membrane associated with age-related macular degeneration, amblyopia treatment, cataract surgery, vitrectomy for vitreous hemorrhage in diabetes, and surgery for proliferative vitreoretinal diabetic retinopathy.

This study aimed to calculate and evaluate the utility value of surgical treatment in patients with cataract, glaucoma, and comitant strabismus, who were experiencing the inconvenience of visual disorders, and to compare their changes using TTO analysis. We evaluated the validity of TTO analysis by examining the correlations of the TTO utility value with the results of VF-14 [14], which is a vision-specific QOL scale [15-20], and visual acuity.

Materials and Methods

Subjects. The subjects were 222 patients aged 40-85 years, including 45 patients with glaucoma, 88 with cataracts, and 89 with comitant strabismus who were surgically treated at the Okayama University Hospital between January 2008 and March 2010. Of these 222 patients, 127 patients, including 26 with glaucoma, 50 with cataracts, and 51 with comitant strabismus, answered the questionnaire. All gave informed consent according to a protocol conforming to the Declaration of Helsinki, approved by the Institutional Review Board of the Okayama University Graduate School of Medicine, Dentistry, and Pharmaceutical Sciences.

Indication of surgical treatment. The surgery for comitant strabismus was determined by considering the impairment of binocular function in daily life in addition to psychological difficulties such as physical features. Concerning glaucoma, patients showing poor control of intraocular pressure with drugs and those showing progression of visual field loss despite adequate control of intraocular pressure were considered to have a surgical indication, and glaucoma surgery by trabeculectomy or trabeculotomy was selected individually. Glaucoma patients who underwent filtering surgery combined with cataract surgery were excluded from this study. Cataract surgery was evaluated by considering the living environment as well as visual acuity, and bilateral surgery was performed at an interval of 1-2 weeks. Phacoemulsification, aspiration and intraocular lens implantation were performed in all patients, and uni- or bilateral surgery was carried out depending on the patient's condition. Cataract cases were divided into 2 groups, uni- and bilateral cataract surgery. Strabismus cases with glaucoma or cataract surgery were excluded from this study. Moreover, glaucoma or cataracts cases who needed strabismus surgery were also excluded from this study.

Measurement of the visual acuity and visual field. The visual acuity was examined at a distance of 5 m. Decimal visual acuity values of less than 0.01 were expressed by the following: Counting fingers was scored as 0.014, and hand motion as 0.005 at 30 cm [21]. For statistical analyses, decimal visual acuity values were converted to log MAR. The visual field was measured in each eye using a Humphrey Field Analyzer II (Carl Zeiss Meditec, USA, SITA Standard™). Mean deviation (MD) scores were used to assess the severity of visual field loss. Severity of visual field loss was classified into 3 stages : $MD > -6dB$ for early stage, $-12\ dB \leqq MD \leqq -6dB$ for intermediate stage, and $MD < -12$ dB for late stage loss [22].

Pre- and postoperative VF-14 scores and TTO measurements. A VF-14 questionnaire and a TTO measurement sheet were mailed to the patients 2 to 3 months postoperatively, and the pre- and postoperative scores of these measures were entered. We instructed patients that they must complete the questionnaire themselves, rather than allowing a caregiver or other acquaintance to do so on their behalf. The questionnaire consisted of the Japanese version of VF-14 [23], and a questionnaire for the TTO utility values. In the TTO utility analysis, patients were told to assume that there was a surgical treatment that would offer them perfect vision if successful, and asked whether they would be willing to trade off some of their expected remaining years for perfect vision. The expected remaining years were based on data from the Japanese Ministry of Health, Labor and

Welfare of 2008. The utility value was calculated using the following equation: Utility value=1-time traded/expected remaining years.

Relationship of TTO and VFQ with visual acuity. The correlations between QOL measures and visual acuity were analyzed to evaluate the relationship between the 2 variables. The pre- and postoperative TTO utility values, total VF-14 scores, and correlation of the corrected visual acuity between the better and worse eyes were calculated.

Relationships of the TTO utility value with other independent variables. To analyze the relationships of the TTO utility value with various variables, multiple regression analysis was carried out. The pre- and postoperative TTO utility values were used as dependent variables, and the pre- and postoperative visual acuities, age, gender, and VF-14 score as independent variables. In addition, the MD score in visual field loss was used as an independent variable in glaucoma, and the size of ocular deviation and the binocular single vision were used as independent variables in comitant strabismus.

Calculation of QALYs. The utility gain was calculated from the pre- and postoperative TTO utility values, and it was assumed that surgery would lead to no change in life expectancy. The number of QALYs gained was calculated by multiplying the measured utility gain and the patient's life expectancy, with an assumed annual discount rate of 3% [24] recommended, by using the following discounting formula by Bauchamp *et al.* [25]:

$$\text{Number of QALYs} = \Delta U \times LE \times \sum_{i=1}^{LE} 1/(1+DR)^{i-0.5},$$

where ΔU is the measured mean utility gain, LE is life expectancy and DR is discount rate.

Statistical analysis. The chi-square test was used to compare the difference in distribution in the clinical characteristics of the 4 treatment groups. To compare the pre- and postoperative TTO utility values and the VF-14 score, the *t*-test was used. Pearson's correlation coefficient was used to analyze the relation between pre- and postoperative utility values, and between the VF-14 score and visual acuity. Multiple regression analysis was used to assess the coefficient of determination using pre- and postoperative TTO utility values as dependent variables. Analyses were done using the statistical software package JMP (ver. 8.0; SAS Institute Inc., NC, USA).

Results

Response rates to the questionnaire (Table 1). There was no marked difference in response rates to the questionnaire among the 4 treatment groups: the rates were 57.3% for comitant strabismus, 57.8% for glaucoma, 56.8% for unilateral cataract, and 57.2% for bilateral cataract.

Characteristics of the analyzed subjects (Table 1). The mean ages (SD) of patients with comitant strabismus, glaucoma, unilateral and bilateral cataracts were 62.7 (10.8), 69.6 (11.7), 70.9 (10.9), and 74.5 (5.8), respectively. The male: female ratios of these patients were 25: 26, 12: 14, 14: 7, and 17: 12, respectively. The disease type of comitant strabismus was exotropia in 43 (84.3%) and esotropia in 8 patients (15.7%). The preoperative mean far deviation (SD) was 44.8 (18.4) prism diopters (pds.), and postoperatively it was 7.8 (9.8) pds., with a mean rate of correction (SD) of 82.2% (23.0). Eight patients (15.7%) showed binocular single vision at distance with the Bagolini striated glasses test preoperatively, and 32 patients (62.7%) did so postoperatively.

The disease type of glaucoma was primary open angle glaucoma in 12 (46.2%), primary angle closure glaucoma in 1 (3.8%), secondary with exfoliation glaucoma in 8 (30.8%), and other types in 5 patients (19.2%). The preoperative mean MD of the better eye was −6.9 dB, and postoperatively it was −6.5 dB, with no significant difference between the pre- and postoperative MD value (p=0.867, *t*-test). The preoperative proportion ratios of the number of patients classified in the 3 stage, early, intermediate, and late stage of visual field loss of the better eye were 52.1%, 26.1%, and 21.7%, and the corresponding postoperative ratios were 58.3%, 16.7%, and 25.0%, with no significant difference between the 3 stage pre- and postoperative proportion rate (chi square test, p= 0.868). Moreover, we calculated the medication scores, and compared the pre- and postoperative values by scoring 1 point per instillation and 2 points per internal medicine dose. The percent rate of patients who stopped using medication increased from 0% to 36.4% postoperatively. The mean medication score (SD) was significantly decreased from 3.18 (0.75) to 0.82 (0.87) postoperatively (p=0.001, *t*-test).

Cataract was age-related in all patients, and those

Table 1 Preoperative clinical characteristics

	Comitant strabismus	Glaucoma	Unilateral cataract	Bilateral cataract	*P*
Enrolled patients	89	45	37	51	
Responder	51	26	21	29	
Gender, Number					0.3411
Male	25 (49%)	12 (46%)	14 (67%)	17 (59%)	
Female	26 (51%)	14 (54%)	7 (33%)	12 (41%)	
Age, yrs.					0.4252
Mean (SD)	62.7 (10.8)	69.6 (11.7)	70.9 (10.9)	74.5 (5.8)	
≥80	3 (6%)	6 (23%)	5 (24%)	6 (21%)	
60≤ <80	28 (55%)	16 (62%)	12 (57%)	22 (76%)	
40≤ <60	20 (39%)	4 (15%)	4 (19%)	1 (3%)	
VA in better eye					0.2922
Mean (SD), decimal	1.2 (0.3)	1.0 (0.3)	0.9 (0.5)	0.7 (0.3)	
≥1.0	46 (90%)	17 (65%)	11 (52%)	8 (28%)	
0.5≤ <1.0	3 (6%)	7 (27%)	5 (24%)	14 (48%)	
<0.5	2 (4%)	2 (8%)	5 (24%)	7 (24%)	
VA in worse eye					0.4083
Mean (SD), decimal	0.9 (0.4)	0.6 (0.5)	0.3 (0.3)	0.4 (0.3)	
≥1.0	34 (67%)	8 (31%)	0	1 (3%)	
0.5≤ <1.0	9 (18%)	8 (31%)	8 (38%)	12 (41%)	
<0.5	8 (16%)	10 (38%)	13 (62%)	16 (55%)	
VF-14 score					0.4252
Mean (SD)	72.3 (21.1)	80.7 (17.5)	73.0 (15.1)	69.8 (21.5)	
Median	72.9	82.0	70.5	72.5	
100≥ ≥80	19 (37%)	15 (58%)	6 (29%)	10 (35%)	
80> ≥40	28 (55%)	10 (39%)	15 (72%)	17 (59%)	
40> ≥0	4 (8%)	1 (4%)	0	2 (6%)	
Utility value					0.1883
Mean (SD)	0.852 (0.124)	0.810 (0.171)	0.727(0.279)	0.663 (0.196)	
1.0	12 (26%)	6 (23%)	4 (22%)	2 (8%)	
1.0> ≥0.5	35 (74%)	19 (73%)	11 (61%)	20 (77%)	
0.5> ≥0.3	0	1 (3%)	2 (11%)	2 (8%)	
0.3> ≥0	0	0	1 (6%)	2 (8%)	

VA, visual acuity; VF-14, visual function questionnare-14.

with corrected visual acuity of 0.5 or less in visual acuity in the worse eye accounted for high percentages (61.9% for unilateral and 55.2% for the bilateral cataract surgery group).

Results of VF-14 (Tables 1 and 2). The VF-14 Questionnaire was completed by 51 patients with comitant strabismus, 26 with glaucoma, and 50 with cataracts, for a total of 127 (57.2%). The preoperative score was 80 or higher in a higher percentage of patients with glaucoma compared with the other 3 groups, but the postoperative score showed no difference in distribution among the 4 groups. The mean (SD) of the difference between the pre- and postoperative scores was 1.5 (16.1) in patients with glaucoma, 11.5 (15.1) in those with unilateral cataracts, 13.5 (16.0) in those with strabismus, and 17.0 (21.3) in those with bilateral cataracts (Fig. 1). The score improved significantly after surgery in the comitant strabismus ($p < 0.0001$, *t*-test), unilateral cataract ($p < 0.0002$) and bilateral cataracts groups ($p = 0.0002$), but not in the glaucoma group ($p = 0.6407$).

Results of TTO utility analysis (Tables 1 and 2). The TTO questionnaire was completed by 47 patients with comitant strabismus, 26 with glaucoma, and 44 with cataracts, for a total of 117 respondents (52.7%). No significant difference was noted in the distribution of utility values among the 4 groups before and after surgery ($p = 0.1883$, chi square test, for pre-, and $p = 0.5986$ for postoperatively). Fig. 2 shows the means (SD) of the pre- and postoperative

Table 2 Postoperative clinical findings

	Comitant strabismus n=51	Glaucoma n=26	Unilateral cataract n=21	Bilateral cataract n=29	*P*
VA in better eye					0.4403
Mean (SD), decimal	1.2 (0.3)	1.0 (0.4)	0.9 (0.4)	1.1 (0.4)	
Median	1.2	1.0	1.0	1.0	
≥1.0	46 (90%)	16 (62%)	13 (62%)	15 (52%)	
0.5≤ <1.0	4 (8%)	8 (31%)	7 (33%)	9 (31%)	
<0.5	1 (2%)	2 (8%)	1 (5%)	5 (17%)	
VA in worse eye					0.1960
Mean (SD), decimal	0.9 (0.4)	0.6 (0.5)	0.6 (0.4)	0.7 (0.4)	
Median	1.0	0.5	0.7	0.7	
≥1.0	31 (61%)	7 (27%)	6 (29%)	7 (24%)	
0.5≤ <1.0	10 (20%)	10 (38%)	11 (52%)	11 (38%)	
<0.5	10 (20%)	9 (35%)	4 (19%)	11 (38%)	
VF-14 score					0.4252
Mean (SD)	85.8 (14.8)	82.2 (17.3)	84.5 (11.0)	86.8 (15.1)	
Median	88.6	86.8	83.9	89.6	
100≥ ≥80	35 (69%)	17 (65%)	13 (62%)	22 (76%)	
80> ≥40	16 (32%)	9 (35%)	8 (38%)	7 (24%)	
40> ≥0	0	0	0	0	
Utility value					0.5986
Mean (SD)	0.952 (0.07)	0.906 (0.140)	0.894 (0.228)	0.909 (0.155)	
1.0	21 (45%)	7 (27%)	7 (39%)	12 (46%)	
1.0> ≥0.5	26 (55%)	18 (69%)	10 (56%)	13 (50%)	
0.5> ≥0.3	0	1 (4%)	0	0	
0.3> ≥0	0	0	1 (6%)	1 (4%)	
Utility gain					0.4666
Mean	0.101 (0.105)	0.096 (0.105)	0.167 (0.237)	0.245 (0.167)	
1.0> ≥0.5	0	0	1 (6%)	1 (4%)	
0.5> ≥0.3	2 (5%)	2 (8%)	3 (17%)	8 (31%)	
0.3> ≥0.1	19 (40%)	7 (27%)	5 (28%)	13 (50%)	
0.1> ≥0	26 (55%)	17 (65%)	9 (50%)	4 (15%)	

VA, visual acuity; VF-14, visual function questionnare-14.

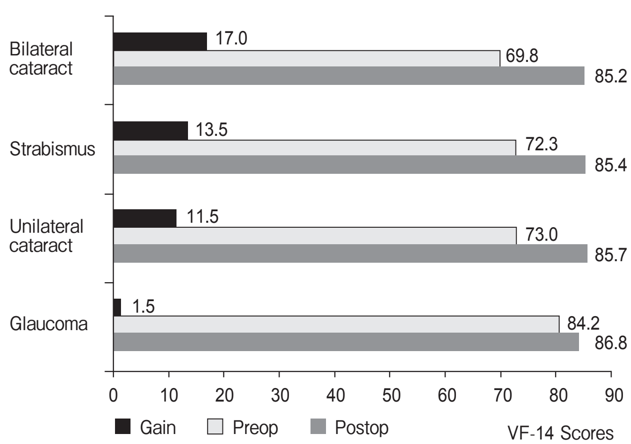

Fig. 1 Mean pre- and postoperative VF-14 scores in the 4 treatment groups.

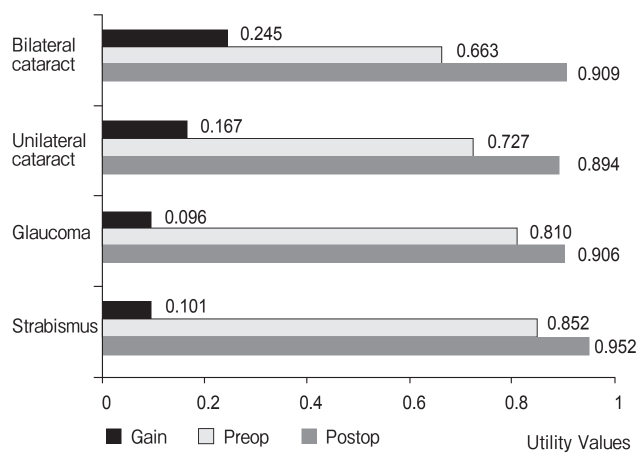

Fig. 2 Mean pre- and postoperative values of TTO utility in the 4 treatment groups.

utility values and utility gain (postoperative utility value-preoperative utility value), respectively. The TTO utility value improved significantly postoperatively in all 4 groups. The mean (SD) of the utility gains was 0.096 (0.105) for glaucoma, 0.101 (0.105) for comitant strabismus, 0.167 (0.237) for unilateral and 0.245 (0.167) for bilateral cataract surgery, and the utility gain was largest for bilateral cataract surgery. However, the utility gain of bilateral cataract surgery was not double that of unilateral surgery, being only 46.7% higher. The numbers of patients who indicated an unwillingness to complete the TTO questionnaire survey before and after surgery and, consequently, had a utility value of 0 were 25.5% (12 patients), 15.4% (4), 22.2% (4) and 7.7% (2) in the comitant strabismus, glaucoma, and uni- and bilateral cataract surgery groups, respectively, being highest in the comitant strabismus and lowest in the bilateral cataract surgery group.

Correlation between pre- and postoperative TTO utility value, VF-14 scores and other variables (Tables 3 and 4). Preoperatively, no significant positive correlation was observed between the utility value and the VF-14 score in the 4 groups, but postoperatively, a significant positive correlation was noted in the bilateral cataract surgery group ($r=0.588$, $p=0.002$). The preoperative utility value showed no significant correlation with the corrected visual acuity of the better or worse eye of the 4 treatment groups, but the postoperative utility value showed a significant negative correlation with the corrected visual acuity of the better eye in the unilateral cataract group ($r=-0.652$, $p=0.003$). For the VF-14 score, a significant correlation was observed with the preoperative visual acuity of the better eye in the comitant strabismus ($r=-0.285$, $p=0.04$), glaucoma ($r=-0.440$, $p=0.025$) and bilateral cataract groups ($r=-0.417$, $p=0.024$), and with the postoperative visual acuity of the better eye in the glaucoma ($r=-0.480$, $p=0.013$) and bilateral cataract groups ($r=-0.406$, $p=0.029$). Moreover, the VF-14 score was significantly correlated with the preoperative visual field loss in the better ($r=0.487$, $p=0.008$) and worse eye ($r=0.423$, $p=0.044$) in the glaucoma group.

Table 3 Relationship between preoperative utility value, VF-14 score, and other variables

Comitant strabismus n=47	Utility value	VA in better eye	BSV	Ocular deviation	VA in worse eye
VF-14 score	0.214 (0.150)	−0.285* (0.04)	0.077 (0.607)	0.198 (0.163)	0.200 (0.147)
Utility value		0.217 (0.144)	0.127 (0.424)	−0.117 (0.431)	−0.118 (0.435)
VA in better eye			0.306* (0.048)	−0.072 (0.616)	0.248 (0.080)
BSV				0.171 (0.254)	0.344* (0.021)
Ocular deviation					0.105 (0.465)

Glaucoma n=26	Utility value	VA in better eye	VA in worse Eye	VFL in better eye	VFL in worse eye	Medication score
VF-14 score	−0.046 (0.823)	−0.440* (0.025)	0.315 (0.628)	0.487* (0.019)	0.423* (0.044)	−0.017 (0.959)
Utility value		−0.158 (0.440)	−0.205 (0.315)	0.232 (0.288)	−0.057 (0.795)	0.412 (0.208)
VA in better eye			0.388 (0.050)	−0.536* (0.008)	−0.311 (0.148)	−0.182 (0.592)
VFL in better eye					0.541* (<0.0001)	0.092 (0.813)

Unilateral cataract n=18	Utility value	VA in better eye	VA in worse eye
VF-14 score	0.012 (0.962)	−0.157 (0.495)	−0.395 (0.077)
Utility value		−0.241 (0.337)	−0.267 (0.280)
VA in better eye			0.477* (0.029)

Bilateral cataract n=26	Utility value	VA in better eye	VA in worse eye
VF-14 score	0.033 (0.874)	−0.417* (0.024)	0.216 (0.261)
Utility value		−0.247 (0.223)	0.510 (0.806)
VA in better eye			0.612* (0.0004)

VA, visual acuity; BSV, binocular single vision; VFL, visual field loss.

Table 4 Relationship between postoperative utility value, VF-14 score, and other variables

Comitant strabismus n=47	Utility value	VA in better eye	VA in worse eye	BSV	Ocular deviation	Percent decrease in ocular deviation
VF-14 score	−0.202 (0.171)	−0.352 (0.114)	0.105 (0.682)	−0.086 (0.479)	0.056 (0.694)	0.186 (0.191)
Utility value		0.049 (0.742)	−0.041 (0.787)	−0.159 (0.873)	−0.082 (0.584)	0.081 (0.536)
VA in better eye			−0.053 (0.712)	−0.113 (0.354)	−0.125 (0.382)	0.075 (0.602)
BSV					0.473* (0.0001)	0.432 (0.0004)
Glaucoma n=26	**Utility value**	**VA in better eye**	**VA in worse eye**	**VFL**	**VFL in worse eye**	**Medication score**
VF-14 score	0.047 (0.817)	−0.480* (0.013)	−0.184 (0.366)	0.129 (0.719)	0.611 (0.061)	−0.277 (0.410)
Utility value		0.055 (0.793)	−0.232 (0.255)	0.122 (0.706)	0.212 (0.532)	−0.130 (0.704)
VA in better eye			0.342 (0.087)	−0.671* (0.017)	−0.367 (0.263)	−0.277 (0.426)
VFL in better eye					0.564* (0.004)	0.314 (0.493)
Unilateral cata ractn=18	**Utility value**	**VA in better eye**	**VA in worse eye**			
VF-14 score	0.145 (0.566)	−0.303 (0.181)	−0.338 (0.134)			
Utility value		−0.652* (0.003)	−0.148 (0.558)			
VA in better eye			0.351 (0.118)			
Bilateral cataract n=26	**Utility value**	**VA in better eye**	**VA in worse eye**			
VF-14 score	0.588* (0.002)	−0.406* (0.029)	−0.201 (0.295)			
Utility value		−0.125 (0.542)	−0.139 (0.498)			
VA in better eye			0.596* (0.006)			

VA, visual acuity; BSV, binocular single vision; VFL, visual field loss.

Relationships of the TTO utility value with visual acuity and other independent variables (Tables 5 and 6). Since the correlation coefficient between the visual acuities of the better and worse eyes was moderately significant pre- or postoperatively in the 4 groups, the variables of the worse eye were excluded from the independent variables in the multiple regression analysis. Similarly, because there was a strong correlation between the MD values of the better and worse eyes in the glaucoma group, the MD value of the worse eye was excluded from the variables of the multiple regression analysis. Preoperatively, the coefficient of determination in comitant strabismus was 0.4112 (p=0.0113). The only independent variable that was significant for comitant strabismus was being male. Thus, the utility value tended to be higher in males in the comitant strabismus group. Postoperatively, the coefficient of determination was 0.6045 (p=0.0408) in the bilateral cataract surgery group. The VF-14 score was a significant independent variable in the bilateral cataract surgery group. Although the coefficient of determination was not significant (p=0.0584), the corrected visual acuity of the better eye was a weak candidate independent variable in the unilateral cataract surgery group (p=0.0206). Thus, the TTO utility value tended to be higher as the VF-14 score was higher in the bilateral cataract surgery group, and as corrected visual acuity of the better eye was better in the unilateral cataract surgery group.

Calculation of QALYs. Fig. 3 shows the mean (SD) of the QOLYs gained calculated by multiplying the utility value by the life expectancy and assuming annual discount rates of 3%, 5%, and 10%. The QALYs assuming an annual discount rate of 3% was 0.870 (0.898) in glaucoma surgery, 1.132 (1.148) in comitant strabismus, and 1.424 (1.817) in unilateral and 2.181 (1.520) in bilateral cataract surgery, being highest for bilateral cataract surgery. However, the mean of the QALYs gained by bilateral surgery was only 53% higher than that by unilateral surgery.

Discussion

Utility analysis was performed by measuring the

Table 5 Multiple regression analysis with the preoperative utility value as a dependent variable

	Partial correlation coefficient	*P*-value
Comitant strabismus (n=47)		
Age	−0.0008	0.7144
Gender	−0.0480	0.0068*
VF-14 score	0.0016	0.0865
Type	−0.0920	0.1751
Visual acuity in better eye	0.2084	0.1281
Preoperative deviation	−0.0008	0.4196
Preoperative binocular vision	0.0262	0.3699
Coefficient of determination (*p*-value)		0.6567 (0.0236)
Glaucoma (n=26)		
Age	−0.0053	0.1040
Gender	0.0759	0.0485
VF-14 score	−0.0031	0.2075
Visual acuity in better eye	−0.2748	0.3105
Visual field loss in better eye	0.0076	0.2687
Coefficient of determination (*p*-value)		0.5961 (0.1521)
Unilateral cataract (n=18)		
Age	−0.0127	0.1436
Gender	0.0196	0.7916
VF-14 score	0.0032	0.5906
Visual acuity in better eye	0.0412	0.8644
Coefficient of determination (*p*-value)		0.2288 (0.4595)
Bilateral cataract (n=26)		
Age	−0.0100	0.1647
Gender	−0.0023	0.9564
VF-14 score	−0.0015	0.4904
Visual acuity in better eye	−0.2055	0.1559
Coefficient of determination (*p*-value)		0.1574 (0.4390)

pre- and postoperative utility values using the TTO method. The preoperative utility value was highest at 0.852 for comitant strabismus, followed by 0.810 for glaucoma, and 0.727 for unilateral and 0.663 for bilateral cataracts. The TTO technique can also be used for comparisons with systemic diseases, unlike assessment instruments of vision-related QOL such as the VF-14 [14] and VFQ-25 [19, 20]. When the results of the present study are compared with those of previous studies, the utility value of comitant strabismus is between those of moderate angina pectoris and myocardial infarction, that of glaucoma is equivalent to that of moderate myocardial infarction, and that of cataracts is equivalent to moderate osteoarthritis of the hip [6, 16].

Since vision-related QOL measurement instruments such as the VF-14 and VFQ-25 do not necessarily correlate with TTO, they are not usually used to analyze cost-effectiveness or cost-utility [16]. However, in the present study, significant correlations were observed between the postoperative TTO utility values and VF-14 scores in bilateral cataracts. If there is a significant relationship between the preoperative TTO utility value and VF-14 score, the VF-14 can be utilized to analyze cost-effectiveness. The TTO method is also applicable to QOL measurement in cataracts such as dry eye [26].

The corrected visual acuity of the better eye has been reported as an important factor related to TTO [3, 6, 11, 16, 27, 28]. In the present study, significant correlations were also noted between the utility value and corrected visual acuity of the better eye of the postoperative unilateral cataract. Significant correlations were noted between the VF-14 score and corrected visual acuity of the better eye in the pre- and postoperative glaucoma and bilateral cataract groups. The TTO utility value is considered to accurately reflect the state of activities of daily living affected by visual impairment similarly to the VF-14 score, and TTO can be regarded as a suitable method for direct measurement of the utility value.

The TTO utility value improved significantly compared with that before surgery in all 4 treatment groups. In the present study, the utility gain was largest in cataract surgery and was larger in bilateral than unilateral surgery. In Japan, a utility analysis of bilateral cataract surgery using TTO was reported by Senba [28], who observed a utility gain close to that in the present study (0.226 reported by Senba vs. 0.245 in the present study). The utility analyses of cataract surgery to date have revealed 2 characteristics. One is that the utility gain differs between developed and developing countries, with the gain being smaller in developed countries (0.159 vs. 0.190)

Table 6 Multiple regression analysis with the postoperative utility value as a dependent variable

	Partial correlation coefficient	*P*-value
Comitant strabismus (n=47)		
Age	0.0003	0.8330
Gender	−0.0190	0.0748
VF-14 score	−0.0006	0.4533
Type	−0.0267	0.8311
Visual acuity in better eye	−0.0143	0.9092
Preoperative deviation	−0.0002	0.8990
Preoperative binocular vision	0.0060	0.6840
Coefficient of determination (*p*-value)		0.4214 (0.7412)
Glaucoma (n=26)		
Age	−0.0059	0.3517
Gender	0.0316	0.6505
VF-14 score	−0.0126	0.1718
Visual acuity in better eye	0.0890	0.8075
Visual field loss in better eye	0.0210	0.1812
Coefficient of determination (*p*-value)		0.4827 (0.4393)
Unilateral cataract (n=18)		
Age	0.0012	0.8088
Gender	0.0545	0.3251
VF-14 score	−0.0007	0.9030
Visual acuity in better eye	−0.6538	0.0206
Coefficient of determination (*p*-value)		0.4805 (0.0584)
Bilateral cataract (n=26)		
Age	−0.0004	0.9393
Gender	−0.0027	0.9243
VF-14 score	0.0063	0.0152*
Visual acuity in better eye	0.0842	0.4616
Coefficient of determination (*p*-value)		0.604 (0.0408)

[29]. The other is that the utility gain is greater in the first than the second surgery (0.148 vs. 0.109) [30, 31]. If the unilateral surgery in the present study is assumed to be the first surgery, the utility gain (0.167) is close to that in developed countries. Also, if the difference in the utility gain between bilateral and unilateral surgery is assumed to be the utility gain of the second surgery, it is calculated as 0.078 in this study, similar to the previous study, and is smaller than that in the first surgery. Thus, the effect of unilateral surgery on the vision-related QOL is considered to be extremely large.

The utility gain following strabismus surgery in adults analyzed using TTO was greater in the previous (0.1175) [25, 32] than in the present (0.101) study. The reasons are as follows. In contrast to our study, the previous study analyzed the utility gain without differentiating comitant from incomitant strabismus. Diplopia encountered in cases of incomitant strabismus could influence daily QOL. Therefore, dissolution of diplopia by surgery could greatly increase the utility value. On the other hand, compared to our results, the mean utility value of the Japanese multicenter study of comitant strabismus was lower [0.101 (0.105) for our study vs. 0.06 (0.16) for the multi-center study] [33]. This difference could be attributable to the large distribution of surgical results among facilities participating in this study.

There has been no study on the utility analysis of glaucoma surgery using TTO other than this one. The present study revealed characteristics of utility analysis. The utility gain in glaucoma was almost equal to that in comitant strabismus, although the visual acuity, as well as the visual field loss, remained unchanged postoperatively. One reason for this finding was that the proportion of patients who stopped using either eye drops or internal medicine increased from

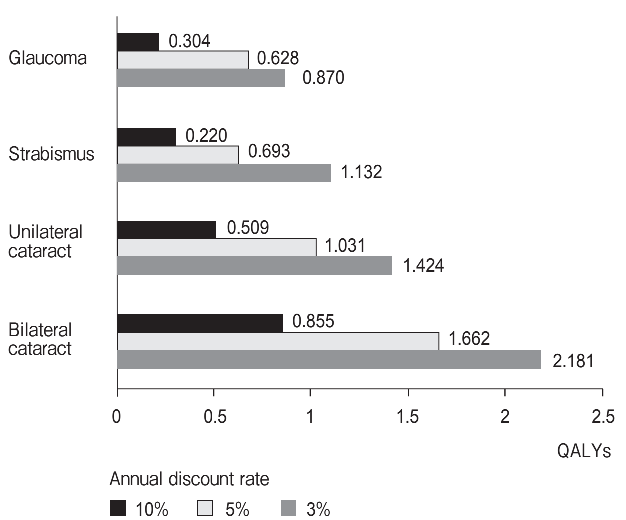

Fig. 3 Mean QALYs for the 4 treatment groups calculated with annual discount rates of 3%, 5%, and 10%.

0% to 36.4% postoperatively. Second, the glaucoma operation has a psychological effect in that fear of blindness can be reduced.

Multiple regression analysis revealed the characteristics of each disease. Preoperatively, the utility value was high in males in the comitant strabismus group. Postoperatively, the utility value was correlated with the VF-14 score in the bilateral cataract group. Visual field loss, which is an important symptom of glaucoma, showed no correlation with the VF-14 or TTO score on simple linear or multiple regression analysis. This finding supports the results reported by Gupta [34]. There are, however, reports showing correlations [35, 36], and the relationship between visual field loss and TTO remains controversial.

The mean of the QALYs gained by surgical treatment was 1.0 or greater in all 3 surgical intervention groups evaluated in this study (Fig. 3). Concerning the individual groups, the mean of the QALYs gained was large in the strabismus group, with the exception of the patients with cataracts. This is considered to have been due to the improvement in the QOL and resultant improvement in the TTO score. For patients with strabismus, the socioeconomic disadvantages and psychological effects have come to be perceived as problems [32]. In Japan, there has been a multicenter analysis of the effect of strabismus surgery on QOL using the NEI VFQ-25 and a report on the effectiveness of strabismus surgery on QOL [33].

There were several limitations in the present study. The first is that the study was retrospective. This is considered to be the reason why a significant correlation could not be demonstrated preoperatively between the TTO and VF-14 score or corrected visual acuity in the 3 diseases, although these correlations were suggested by a previous study [28]. The second is the possibility of bias in the results because the subjects were limited to those at our clinic, rather than multiple facilities. However, no marked difference was noted compared with the results of previous studies concerning strabismus [32] or cataract surgery [28-31]. Therefore, the bias is likely to have been negligible. The third is related to comorbidities. However, as the utility value is generally considered not to be affected by comorbidities other than the primary disease [37], utility values related to comorbidities were not analyzed in this study. The fourth is the lasting effect of surgical intervention. Calculation of QALYs is based on the assumption that the effect of surgical intervention lasts for the whole lifetime. This may be true in the case of cataract surgery and in some patients with adult comitant strabismus [38, 39]. However, it is apparent that some patients with strabismus or glaucoma require additional surgery in the future. For these reasons, the QALYs gain was calculated with assumed annual discount rates of 3%, 5%, and 10%, respectively. The fifth is the number of patients undergoing TTO utility analysis was smaller than the number undergoing VF-14 analysis. Therefore, TTO utility analysis may not accurately represent the characteristics of all patients.

In conclusion, both the TTO and VF-14 score are related to the postoperative visual acuity of the better eye in unilateral cataracts, and the VF-14 score to that in bilateral cataracts; the utility values are thus considered to be valid for use in cataract surgery.

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