# The National Survey of Trabeculectomy. II. Variations in operative technique and outcome

# Abstract

Purpose There is a considerable body of literature relating to trabeculectomy; however, there are no data representative of the national experience of trabeculectomy in the United Kingdom (UK). The Department of Health funded a national survey of trabeculectomy to establish current practice patterns and the outcome of trabeculectomy in the National Health Service (NHS). In this paper we report variations in surgical technique and the national success rate of trabeculectomy. Methods A cross-sectional survey was carried out of consultant ophthalmologists performing trabeculectomy in the NHS. Participants recruited their four most recent consecutive first-time trabeculectomy cases according to study eligibility criteria and data were collected by self-administered questionnaire. Follow-up: 1 year posttrabeculectomy. Main outcome measure of success: final intraocular pressure (IOP) less than two-thirds the pre-operative IOP. Secondary outcome measures of success: final IOP less than 21 mmHg and visual field stability. Success was further defined as unqualified (excluding patients on antiglaucoma medications at final follow-up) or qualified (including patients on anti-glaucoma medications at final follow-up). The relationship between variables characterising consultants' practice and main outcome measure was examined by chi-square test. Results Clinical outcome data were available for 1240 (85.3%) cases. There were wide variations in operative technique. The mean post-operative IOP was 14.4 mmHg (95% CI 14.2-14.7), which is a mean reduction of 11.8 mmHg (95% CI 11.4-12.2). An unqualified success, in terms of the main outcome measure, was achieved in 66.6% of patients and a qualified success in 71.0% of cases. An unqualified success, in terms of a final IOP less than 21 mmHg, was achieved in 84.0% of cases and a qualified success in 92.0%. Visual fields were stable in 84.2%. Outcome was not related to consultants' specialist interest, level of activity, type of hospital or region. Conclusions The success rates reported in this paper represent the national experience of first-time trabeculectomy for open angle

# glaucoma in the UK. The national success rate at 1 year compares favourably with many studies in the literature. This survey provides valid and clinically relevant measures of success for the production of guidelines and standards for audit at regional, local and individual level and a baseline for the comparison of new therapies.

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*Key words* Intraocular pressure, National survey, Outcomes, Trabeculectomy

The National Survey of Trabeculectomy is a large cross-sectional study of current practices of trabeculectomy in the United Kingdom (UK). Although there are many reports in the literature of the outcome of trabeculectomy, most are single-surgeon series and are restricted to specific clinic populations. This survey was designed to provide evidence of the practice of ophthalmologists performing trabeculectomy and the outcomes of first-time trabeculectomy relevant to a UK population of patients and practitioners. The first report from this survey described survey methods, the demography and the clinical characteristics of the sample.<sup>1</sup> In this paper we describe variations in the operative technique and the outcome of trabeculectomy in terms of success.

The vast range of definitions of trabeculectomy success used in the literature is testimony to the difficulty of determining an appropriate outcome measure for this operation. Ultimately the aim of surgery must be to retard or halt glaucomatous visual field loss. However, the performance and interpretation of visual fields is highly problematic and detection of progression is difficult even in experienced hands.<sup>2</sup> Intraocular pressure (IOP) is easier to measure than visual field progression and has been used as a surrogate measure of surgical success since the introduction of trabeculectomy. Historically, success is usually reported in terms of a postoperative IOP reduction below a level of around 21 mmHg although increasingly tonometric outcome measures that use a proportionate criterion are being used.<sup>3–10</sup>

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# Methods

All consultant ophthalmologists performing trabeculectomy in the UK were invited to select the four most recent consecutive trabeculectomies performed on patients under their care prior to 18 June 1996. Data were collected by self-administered questionnaires at baseline and 6 and 12 months post-operatively. A detailed description of the methods, including validation and non-response studies, is published elsewhere.<sup>1</sup> The main outcome measure of trabeculectomy success was defined as an IOP at 1 year following trabeculectomy of less than two-thirds the pre-operative IOP (as measured when listing the patient for surgery). Secondary outcome measures of success were an IOP less than 21 mmHg (to

<b>Tuble 1.</b> Variation in operative features	Table	1.	Variation	in	operative	features
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Variable	Category	Number	%
Eye	Right	627	50.6
	Left	613	49.4
	Missing data	0	
Anaesthetic	General anaesthetic	424	35.7
	Peribulbar	555	46.8
	Retrobulbar	105	8.8
	Subconjunctival	38	3.2
	Sub-Tenon's	59	5.0
	Topical	6	0.5
	Missing data	53	
Grade of surgeon	Consultant	727	58.6
	Senior registrar	99	8.0
	Registrar	199	16.0
	Senior house officer	115	9.3
	Associate specialist	55	4.4
	Other	45	3.6
	Missing data	0	
Site of trabeculectomy	Superior	946	79.5
	Supero-nasal	136	11.4
	Supero-temporal	109	9.2
	Missing data	50	
Traction suture	Yes	1034	90.5
	No	109	9.5
	Missing data	97	
	Cornea	103	10.0
	Superior rectus	924	90.0
	Missing data	7	
Conjunctival flap base	Fornix	874	71.4
, 1	Limbus	350	28.6
	Missing data	16	
Paracentesis	Yes	411	35.3
	No	752	64.7
	Missing data	77	
Shape of scleral flap	Rectangular	943	78.8
F	Triangular	201	16.8
	Other	53	4.4
	Missing data	43	
Punch	Yes	225	19.8
	No	915	80.2
	Missing data	100	00.
Cyclodialysis	Yes	19	17
eyere analysis	No	1128	983
	Missing data	93	2010
Peripheral iridectomy	Vos	1220	08.0
r enpheral indectomy	No	1220	90.9
	Missing data	5	1.2
Antimatabalitas	Vec	70	
Antimetabolites	Tes No	/9 1156	6.4
	Missing data	1130	73.0
Delegendele entreter	No.		
Releasable sutures	res	200	16.4
	INU Missing data	1017	83.6
	1v11001112 uutu	23	

Table 2.	Dose and	method	of	intraoperative	antimetabolite	application
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		5-Fluo	rouracil		Mitomycin-C	2
Variable	Category	n	%		n	%
Dose (mg/ml)	<25.0	16	30.8	0.2	2	40.0
	25.0	32	61.5	0.4	2	40.0
	50.0	4	7.7	0.5	1	20.0
	Missing data	18	-		0	-
Application	Sponge	62	91.2		5	100.0
	Subconjunctival	6	8.8		0	
	Missing data	2	_		0	-
Duration of sponge	1	1	1.7		0	0.0
ຼາplication (min)	2	2	3.3		0	0.0
	3	10	16.7		1	20.0
	4	1	1.7		1	20.0
	5	46	76.7		3	60.0
	Missing data	2	-		0	-

allow comparison with the literature) and visual field stability at 1 year. Both tonometric measures were further defined as qualified or unqualified depending on whether the patient was on post-operative anti-glaucoma medication or not respectively. Cases undergoing further trabeculectomy during this period were regarded as failures.

Associations between explanatory variables characterising consultant practice (self-reported specialist glaucoma interest, university or district general hospital practice, activity level and region) and the main outcome measure of success were measured by the chisquared test with statistical significance at p < 0.05. A consultant's activity level was determined by the number of trabeculectomies they reported performing in the year prior to the survey. This was recoded as a categorical variable for ease of tabulation as there was no difference in statistical inference when treated as either a continuous or categorical variable. South West was used as baseline for chi-square analysis of region and outcome because it was numerically the largest category and had an average success rate.

## Results

Clinical outcome data from the visit closest to 1 year following trabeculectomy were available for 1240 (85.3%) cases (reasons for failure of follow-up are reported elsewhere<sup>1</sup>). There were no significant differences in demographic or baseline clinical characteristics between those patients for whom final clinical outcome data were available and those for whom they were not (full tabulation available on the *Eye* website).

## **Operative** details

Trabeculectomy was performed on 627 (50.6%) right eyes and 613 (49.4%) left eyes. Eight hundred and sixteen (68.8%) cases were performed with local anaesthetic and 424 (35.7%) with general anaesthetic. Peribulbar anaesthesia was the most frequently used local technique. In 727 (58.6%) cases the consultant performed the surgery. Table 1 presents further details of the surgical technique. Intraoperative antimetabolites were used in 79 (6.4%) cases. 5-Fluorouracil (5FU) accounted

Table 3. Dij	fferences in	trabeculectomy	technique	between	specialist	and	non-specialist	consultants
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Variable	Category	Specialist n (%)	Non-specialist n (%)	p value
Type of anaesthetic	Peribulbar	118 (43.7)	437 (47.7)	_
	General	113 (41.9)	311 (33.9)	0.047
	Retrobulbar	21 (7.8)	84 (9.2)	0.771
	Sub-Tenon's	11 (4.1)	48 (5.2)	0.693
	Subconjunctival	7 (2.6)	31 (3.4)	0.682
	Topical	0	6 (0.7)	0.204
Traction suture	Superior rectus	195 (80.9)	729 (92.7)	_
	Corneal	46 (19.1)	57 (7.3)	< 0.0001
Scleral flap	Rectangular	196 (71.8)	747 (80.8)	_
*	Triangular	62 (22.7)	19 (15.0)	0.002
	Other	15 (5.5)	38 (4.1)	0.193
Intraoperative antimetabolites	No	238 (85.3)	918 (96.0)	_
	Yes	41 (14.7)	38 (4.0)	< 0.0001
Post-operative 5FU	No	265 (94.6)	940 (97.9)	_
*	Yes	15 (5.4)	20 (2.1)	0.004
Releasable sutures	No	256 (91.4)	918 (95.6)	_
	Yes	24 (8.6)	42 (4.4)	0.001

5FU, 5-fluorouracil.



**Fig. 1.** Scatterplot of pre-operative and post-operative intraocular pressure.

for 88.6% of these, mitomycin-C (MMC) for 6.3% and  $\beta$ irradiation for 5.1%. There was wide variation in dosage strength and type and duration of application for 5FU and MMC (Table 2). 5FU was administered most frequently by a soaked sponge with a median strength of 25 mg/ml. Post-operative topical steroids were used in 1222 (98.9%) cases. Anti-glaucoma drops were prescribed in 157 (12.7%) cases in the year following trabeculectomy.

In 66 (5.3%) cases releasable sutures were released or permanent sutures cut by laser. The bleb was needled in 21 (1.7%) cases and 35 (2.8%) cases had post-operative subconjunctival 5FU injections. Five (0.4%) cases underwent further trabeculectomy in the year following initial trabeculectomy; these cases were regarded as failures. Consultants with a specialist interest in glaucoma were more likely to use general anaesthesia, a corneal traction suture, a triangular scleral flap, intraoperative antimetabolites, post-operative subconjunctival 5FU and releasable sutures (Table 3).

## Outcomes of trabeculectomy

The mean IOP at the final follow-up visit was 14.4 mmHg (95% CI 14.2–14.7). This represents a mean absolute drop of 11.8 mmHg (95% CI 11.4–12.2) and a mean percentage drop of 42.8% (95% CI 41.6–44.0) in the pre-operative IOP. In the scatterplot (Fig. 1) the points below the line of unity represent eyes in which some reduction in IOP was achieved by the final follow-up visit. These IOP calculations include those patients on post-operative anti-glaucoma medications.

Patients with normal tension glaucoma (NTG) had significantly lower final intraocular pressures compared with primary open angle glaucoma (POAG) cases, though the proportionate reduction in each group was similar (Table 4). Although there was no statistically significant difference in absolute final IOP between pseudoexfoliation glaucoma (PXG) and POAG cases, the proportionate reduction was significantly higher, reflecting a higher IOP in PXG cases at listing.

## Success

The main outcome measure of success – a final IOP less than two-thirds the pre-operative pressure excluding patients on anti-glaucoma medication (unqualified success) – was achieved in 66.6% (823 cases, data missing for 4 cases). A qualified success (including patients on

Table 4. Underlying diagnosis, intraocular pressure and success rates

	POAG	NTG	PXG	PDG
Diagnosis	(n = 1105)	(n = 51)	(n = 64)	(n = 20)
IOP at listing				
Mean IOP (mmHg)	26.29	19.96	29.09	26.10
95% CI	25.96-6.62	18.73-21.19	26.94-31.24	23.39-28.81
p value <sup><math>a</math></sup>	-	< 0.0001	<0.0001	0.954
IOP at final follow-up				
Mean IOP (mmHg)	14.58	11.55	14.42	13.65
95% CI	14.30-14.90	10.30-12.80	13.00-15.84	11.80-15.50
p value <sup>a</sup>	-	< 0.0001	0.979	0.444
Proportionate reduction in IOP				
Mean percentage drop	42.5	40.0	48.3	45.1
95% CI	41.3-43.7	33.0-47.1	42.1-54.4	36.2-53.9
p value <sup><i>a</i></sup>	-	0.352	0.033	0.622
Final IOP < two-thirds pre-operative IOP				
% success rate	66.2	64.0	70.3	85.0
p value <sup>a</sup>	-	0.753	0.493	0.077
Post-operative anti-glaucoma medications				
No. of cases (%)	147 (13.3)	1 (2.0)	9 (14.1)1	0
<i>p</i> value <sup><i>a</i></sup>	-	0.018	0.862	0.157

POAG, primary open angle glaucoma; NTG, normal tension glaucoma; PXG, pseudo-exfoliation glaucoma; PDG, pigmentary glaucoma.

<sup>a</sup>p value of diagnostic category compared with baseline (POAG).

Table 5. Outcome at 1	year	post-trabeculectomy	using	different	criteria	for	'success
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				'Success' ci	iterion		
			Unqualified			Qualified	
		п		%	п		%
Final IOP <two-t< td=""><td>thirds P</td><td>823</td><td></td><td>66.6</td><td>878</td><td></td><td>71.0</td></two-t<>	thirds P	823		66.6	878		71.0
Valid denominat Missing data	tor	1236 4	1	00.0	1236 4	1	00.0
Final IOP in mm	ıHg	п	Valid %	Cumulative %	11	Valid %	Cumulative %
≤6	0	1	0.1	0.1	1	0.1	0.1
	1	2	0.2	0.2	2	0.2	0.2
	2	1	0.1	0.3	1	0.1	0.3
	3	2	0.2	0.5	2	0.2	0.5
	4	6	0.5	1.0	6	0.5	1.0
	5	11	0.9	1.9	11	0.9	1.9
	Ŕ	25	2.0	3.9	26	2.1	4.0
7-20	7	16	13	52	17	14	53
- 20	8	71	57	10.9	71	57	11 1
	9	29	23	13.2	29	23	13.4
1997 - 1997 -	10	112	9.0	22.2	115	03	22.7
	11	32	26	24.9	34	27	25.4
	12	131	10.6	25.5	137	11 1	20.4
Station and Long	12	131	10.0	28.0	1.57	24	40.1
Section Section	15	42	J.4	30.9	107	3.0	40.1
	14	110	9.5	40.4	127	10.5	50.5 E( 1
	15	09	5.0	54.0	12	5.8	50.1
and the second s	10	143	11.5	65.5	157	12.7	68.8
A State of the state of the	17	53	4.3	69.8	58	4./	/3.5
A STATE OF STATE	18	89	1.2	77.0	109	8.8	82.3
Beer and the	19	32	2.6	79.6	40	3.2	85.5
	20	55	4.4	84.0	80	6.5	92.0
≥21	21	19	1.5	85.5	31	2.5	94.5
	22	8	0.6	86.2	21	1.7	96.2
	23	3	0.2	86.4	7	0.6	96.7
	24	6	0.5	86.9	15	1.2	98.0
	25	2	0.2	87.1	4	0.3	98.3
	26	2	0.2	87.2	5	0.4	98.7
	27	0	0	87.2	0	0	98.7
	28	0	0	87.2	3	0.2	98.9
	29	1	0.1	87.3	2	0.2	99.1
	30	1	0.1	87.4	5	0.4	99.5
	36	0	0	87.4	1	0.2	99.6
	Total	1082	87.4	87.4	1233	99.6	99.6
	Medications	151	12.2	99.6	NA	NA	-
Failures	Redo trabeculectomies	5	0.4	100.0	5	0.4	100.0
Totals	Valid denominator	1238	100.0	100.0	1238	100.0	100.0
	Missing data	2			2		
	Study total	1240			1240		

IOP, Intraocular pressure; NA, not applicable.

anti-glaucoma medication) was achieved in 71.0% (878 cases, data missing for 4 cases). In terms of achieving an IOP less than 21 mmHg, the unqualified success rate was 84.0% (1043 cases, data missing for 2 cases) and the qualified success rate 92.0% (1138 cases, data missing for 2 cases). An IOP less than 16 mmHg was achieved in

54.6% (676 cases, data missing for 2 cases) (Table 5). There were no significant differences in success rates between the different diagnostic categories (Table 4).

Consultants with a specialist interest in glaucoma did not have significantly different success rates from those who did not report a specialist interest (Table 6). Type of

Table 6. Variations in success rates according to specialist interest, type of hospital and activity level

	0 1		0	
Variable	Category	Number of cases (%)	Success rate (%)	p value
Specialist glaucoma interest	Yes	280 (22.6)	195 (69.6)	
. 0	No	960 (77.4)	628 (65.7)	0.218
Type of hospital	District general	888 (71.6)	583 (65.8)	-
	University	352 (28.4)	240 (68.6)	0.352
No. of trabeculectomies in	≤20	344 (30.9)	233 (65.0)	-
year prior to survey	21–39	427 (38.4)	285 (67.1)	_
	≥40	341 (30.7)	226 (66.5)	0.833
	Missing data	128	-	-

		Success rate					
Region	Number of cases	IOP <2/3 pre-op. IOP	p value <sup>a</sup>	IOP <21 mmHg	p value <sup><math>a</math></sup>		
South West	206	68.0%	-	85.0%	-		
Anglia and Oxford	133	66.9%	0.841	84.2%	0.839		
Northern Ireland	11	54.5%	0.552	90.9%	0.920		
North Thames	67	70.1%	0.738	83.3%	0.740		
North West	122	68.0%	0.989	85.2%	0.956		
North Yorkshire	157	66.2%	0.730	84.1%	0.804		
Scotland	159	59.1%	0.081	78.6%	0.112		
South Thames	127	68.5%	0.918	85.3%	0.951		
Trent	97	64.9%	0.603	85.6%	0.901		
Wales	51	70.6%	0.718	76.5%	0.142		
West Midlands	106	69.8%	0.739	91.5%	0.104		

<sup>a</sup> Chi-square test (with Yates' correction for small numbers where appropriate) comparing region with baseline region (South West).

hospital and activity level were also not significantly associated with success. There were no significant differences in success rates between regions of the UK (Table 7).

In only 713 (57.7%) cases had a visual field been performed during the year following trabeculectomy. Of these cases, stabilisation of the field was reported in 571 (84.2%, data missing for 35 cases).

# Discussion

### Variations in technique

Since Cairns' original description of trabeculectomy<sup>11</sup> numerous modifications have been proposed. The evidence base for many of these consists of single-surgeon series or unmatched cohort studies although there have been proper intervention studies of site of surgery,<sup>12</sup> limbus versus fornix-based conjunctival flap,<sup>13,14</sup> partial versus total tenonectomy,<sup>15</sup> size of scleral flap and block,<sup>16</sup> anterior versus posterior approach,<sup>17</sup> post-operative steroids,<sup>18–20</sup> releasable sutures,<sup>21</sup> argon suture lysis,<sup>22</sup> needling<sup>23</sup> and antimetabolites.<sup>24–28</sup> Table 1 shows that there is wide variation in surgeons' techniques. Consultants with a specialist interest in glaucoma were more likely to use general anaesthesia, a corneal traction suture, triangular scleral flap, antimetabolites and releasable sutures.

## Intraocular pressure

A mean final IOP of 14.4 mmHg is within the range reported by other studies (13.6–17.1).<sup>6,29–38</sup> Fig. 1 shows that the majority of patients experienced a reduction in IOP following trabeculectomy.

Final IOP was significantly lower in NTG cases compared with baseline (POAG), although the proportionate drop was similar. This supports studies reporting that trabeculectomy is effective in achieving a significant IOP reduction in NTG,<sup>39</sup> which in this survey averaged 40% of the pre-operative IOP (with only one patient on post-operative anti-glaucoma medication). Higher pre-operative IOPs and a greater magnitude of IOP reduction after trabeculectomy in patients with PXG have been reported before<sup>40-42</sup> although in our study the final IOP was not significantly different from the POAG group. As pseudoexfoliation is often underdiagnosed<sup>43,44</sup> it is possible that case misclassification has weakened the differences between the two groups.

## Success and failure

This survey uses a main outcome measure of success that accommodates patients with pre-operative pressures less than 21 mmHg (approximately 15% of the group). This measure is more clinically appropriate than a cut-off of 21 mmHg for cohorts such as ours which include NTG and POAG cases with pre-operative pressures less than 21 mmHg. This approach also recognises as successes patients with high pre-operative pressures in whom there has been a considerable reduction in IOP without reaching 21 mmHg as well as patients with lower preoperative pressures with smaller reductions in IOP. This results in a lower success rate (66.6%) than if success were defined more traditionally as a final IOP less than 21 mmHg (84.2%). Both figures have been reported; the latter allows comparison with the literature but the former is considered a more appropriate reflection of the outcome of trabeculectomy for this cohort.

An unqualified success rate of 84.0% (IOP < 21 mmHg, excluding patients on anti-glaucoma medication) compares favourably with other UK studies. In accordance with these studies,  $^{32,37,45-55}$  the success rates are higher when patients on anti-glaucoma medications are included. Studies of primary trabeculectomy, where trabeculectomy is the initial treatment of glaucoma, rather than trabeculectomy after medical treatment has failed, report success rates of approximately 98%,  $^{34,56}$  In this survey primary trabeculectomy accounted for 5.0% of cases<sup>1</sup> and therefore makes a minimal contribution to the overall success rate.

Although it was originally thought that trabeculectomy success stabilised within a year of surgery,<sup>47,57</sup> there is increasing evidence that trabeculectomy failure continues at a steady rate for years post-operatively.<sup>8,35,58</sup> We chose a follow-up period of 1 year for pragmatic reasons, but it can be anticipated that the success rate is likely to decrease with longer follow-up.

## **Consultant characteristics**

Four measures characterising consultants' practice were examined to determine their relationship with success of surgery. None was significantly associated with outcome. The odds of a successful outcome were a fifth higher for consultants reporting a specialist interest in glaucoma, but this was not statistically significant. This may reflect differences in case-mix, as specialist surgeons would be expected to operate on more complex cases with poorer prognoses. However, as this survey was concerned with first-time trabeculectomy for POAG and excluded cases with previous surgery, it is equally plausible that for this patient profile, the difference in performance between specialist and non-specialist is not significant. Examining the relationship between the number of trabeculectomies each consultant reported performing in the year prior to the audit and success served to complete the activity analysis reported in our previous paper.<sup>1</sup> As there is no association between number of trabeculectomies and outcome, weighting cases according to consultants' levels of activity is not required. Regional success rates varied between 54.5% and 70.6%. Although the odds of success were almost half for Northern Ireland compared with baseline (South West), the numbers in this category were too small to be statistically meaningful. Region and type of hospital were also examined in the National Cataract Surgery Survey and similarly were not associated with outcome (P. Desai, personal communication). It may be that these indicators are too blunt to act as discriminants for surgical outcome. Further analysis of the associations between success and study factors characterising the patient and surgical technique will be presented in future publications.

### Conclusions

This paper reports widespread variation in the operative technique of trabeculectomy amongst ophthalmic surgeons in the UK. The success rates are generated from a representative sample of UK patients and practitioners and therefore provide valid figures for the production of guidelines and standards for audit at regional, local or individual level. The national success rate (IOP < 21 mmHg) compares favourably with many studies in the literature. When using the study's main outcome measure of success, a criterion that may be a more clinically relevant measure of success, 66.6% of patients were successfully controlled. The results of this survey can therefore be used for treatment outcome studies that include patients with NTG or those with POAG whose pre-operative pressures are less than 21 mmHg.

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