Research Article

Does Time Under Anaesthesia Matter? Operative Duration As An Independent Predictor Of Airway Morbidity, Postoperative Discomfort And Patient Satisfaction When Endotracheal Tube Securement Is Standardised: A Prospective Observational Study

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Abstract

Background: Peri-oral and airway injury arising from the endotracheal tube (ETT) is usually explained in terms of how the tube was fixed, how large it was and how tightly the cuff was inflated. How long the apparatus remains pressed against peri-oral and periocular tissue has attracted far less scrutiny in elective theatre practice, largely because heterogeneous fixation methods within a cohort make the effect of time difficult to isolate.
Objective: To establish whether the length of an operation independently predicts intraoperative airway and peri-oral morbidity, postoperative discomfort and patient satisfaction in a cohort where every tube was secured by one and the same device.
Methods: Sixty consecutive adults aged 18–60 years of ASA physical status I or II, scheduled for elective surgery under general anaesthesia with orotracheal intubation, were studied prospectively at a tertiary teaching hospital in South India between December 2024 and December 2025. A single integrated stabilisation device was used in every case, so that securement technique could not vary between participants. Actual operative time in minutes served as the exposure. Endpoints comprised tube migration exceeding 1 cm, peri-oral soft-tissue injury, bite-related occlusion of the tube, ocular complication, a composite of these four, postoperative discomfort graded on a visual analogue scale as mild or moderate, and reported satisfaction. Analysis used the Mann–Whitney U test, the Cochran–Armitage trend test, receiver-operating-characteristic (ROC) analysis and logistic regression adjusted for age, sex and ASA status.
Results: Operations lasted a median of 95 min (IQR 68–140). At least one composite event occurred in 28.3% of patients (95% CI 17.5–41.4). Affected patients had spent longer in theatre than unaffected patients (118.8 ± 42.3 versus 94.7 ± 41.2 min; p = 0.041), and the event rate climbed steadily across duration bands (6.7%, 29.6% and 44.4% for ≤60, 61–120 and >120 min; trend p = 0.017). Not one tube displacement or ocular event arose in an operation shorter than 120 min. After adjustment, operative time alone predicted moderate discomfort (OR 2.77 for every additional 30 min, 95% CI 1.41–5.44; p = 0.003) and was inversely related to the highest satisfaction rating (OR 0.49 per 30 min, 95% CI 0.26–0.91; p = 0.024). Discrimination for moderate discomfort was good (AUC 0.824, 95% CI 0.712–0.935), and a cut-point of 80 min yielded 96.2% sensitivity with 58.8% specificity.
Conclusion: Once the manner of tube securement is fixed across a whole cohort, elapsed operating time stands out as the leading, dose-related driver of airway and peri-oral morbidity and of how uncomfortable patients feel afterwards. Time in theatre deserves to be handled as an actionable risk exposure that should prompt deliberate airway reassessment somewhere beyond the 80- to 120-minute mark, instead of being logged passively at the end of the case.

Keywords: Airway management; Endotracheal intubation; Operative time; Postoperative complications; Patient satisfaction; Corneal abrasion.

1. Introduction

Control of the airway through an orotracheal tube continues to be the benchmark technique for general anaesthesia, and how reliably that tube stays where it was placed is a basic determinant of whether the anaesthetic proceeds safely [1,2]. The consequences of losing tube position span the spectrum from irritating to disastrous: migration into a bronchus with consequent desaturation, accidental extubation demanding urgent reintubation in conditions no one would choose, and the circulatory disturbance that accompanies either [3–5]. That such episodes are neither uncommon nor restricted to the intensive care unit was made plain by the Royal College of Anaesthetists' Fourth National Audit Project, which repeatedly implicated dislodgement and displacement in serious perioperative airway events [6].
Research effort has therefore gravitated towards the question of fixation. Adhesive tape, twill ties, sutures and a growing catalogue of proprietary tube holders have been pitted against one another in manikin studies, in

intensive care and in the operating theatre; pooled evidence generally favours purpose-built holders over tape for resisting displacement, and in certain analyses for limiting device-related pressure damage as well [7–11]. Running alongside this is a body of work treating tube calibre, cuff pressure and the mechanics of intubation as the determinants of sore throat and mucosal trauma after surgery [12–14]. The common thread is that the variable under investigation belongs to the equipment or to the operator.

What has received comparatively little attention is the one exposure shared by every intubated patient yet differing enormously between them: the number of minutes for which the apparatus stays in place. The oversight matters. Every mechanism plausibly responsible for peri-oral and periocular harm during anaesthesia is intrinsically cumulative — steady interface pressure against lip and mucosa, adhesive integrity eroding as secretions and skin-preparation fluid collect, traction transmitted repeatedly through the breathing circuit whenever the patient is repositioned, and incomplete lid closure permitting the tear film to evaporate [15–17]. Where duration has featured at all, it has typically appeared as a covariate buried within studies of postoperative sore throat, in which longer anaesthetics have surfaced again and again as a correlate [18–20], or in the ophthalmological literature, where procedures running past 60 minutes to 3 hours are flagged as predisposing to corneal abrasion [21–23]. Seldom has it been the exposure of primary interest, and the mixture of fixation techniques within those cohorts has made its own contribution hard to disentangle.

A cohort in which one device secures every tube offers an unusual chance to settle the matter. Because securement is invariant by construction, whatever differences in airway and peri-oral morbidity emerge between patients cannot be laid at the door of differing fixation, and the influence of operating time becomes estimable with less confounding than is ordinarily attainable. We accordingly analysed a prospectively assembled cohort of adults anaesthetised for elective surgery with a uniform ETT stabilisation device, aiming to quantify how operative duration relates to four clinically meaningful domains — tube displacement, peri-oral soft-tissue injury, ocular complication and bite-related obstruction — and to test whether duration predicts postoperative discomfort and satisfaction once age, sex and physical status are taken into account. Our expectation was that any such relationships would prove graded rather than abrupt, and that duration would survive adjustment.

2. Materials and methods

2.1. Design, setting and ethical approval

The work was carried out prospectively at a single centre, the Department of Anaesthesiology of Saveetha Medical College and Hospital, Saveetha Institute of Medical and Technical Sciences (SIMATS), Chennai, India, over the period December 2024 to December 2025. Clearance was granted by the Institutional Human Ethics Committee of Saveetha Medical College and Hospital under approval number 014/01/2026/IEC/SMCH, and the parent protocol carries the registration CTRI/2026/02/103521 with the Clinical Trials Registry – India. Every participant provided written informed consent before enrolment. Reporting follows the STROBE recommendations for observational research.

The question addressed here is not the one the parent protocol was written to answer. That protocol set out to describe how a standardised ETT stabilisation device performs clinically; the present analysis takes the same prospectively gathered cohort and interrogates operative duration as an exposure. Each variable examined below was captured in real time on the original data-collection form, and no further contact with patients was needed.

2.2. Participants

Adults listed for elective surgery requiring general anaesthesia with orotracheal intubation were screened consecutively. To be eligible a patient had to be between 18 and 60 years of age, of ASA physical status I or II, undergoing elective surgery under general anaesthesia, and expected to be in theatre for more than 60 minutes. Patients were excluded where a difficult airway was anticipated, where teeth were loose or dental pathology was present, where there had been facial trauma or where ocular disease pre-existed, and in all emergency cases. Sixty patients were recruited by convenience sampling, a figure in keeping with comparable single-centre cohorts examining device performance and airway morbidity.

One point deserves explicit statement. Eligibility turned on the duration anticipated preoperatively, whereas the exposure analysed here was the duration actually realised — a quantity that ranged from 20 to 180 minutes and fell at or below 60 minutes in 15 patients. Divergence between the two is an everyday feature of theatre scheduling rather than a protocol deviation, and it supplied precisely the spread in exposure the analysis required.

2.3. Anaesthetic conduct and standardisation of securement

Each patient was assessed preoperatively, with age, sex, ASA physical status, the planned operation and its expected length all documented. Induction and tracheal intubation followed departmental routine using a cuffed polyvinyl chloride ETT. As soon as correct placement had been confirmed by capnography together with bilateral auscultation, the tube was secured — in every single patient — with the same integrated intraoperative stabilisation device. This unit brings together a soft-polymer anatomical clamp for the tube, a built-in bite block and a removable eye shield, with an adjustable fastening arrangement that accepts the range of adult tube sizes. Applying it uniformly meant that fixation method, presence of a bite block and mode of ocular protection were identical across the cohort and therefore incapable of confounding the relationship between duration and outcome.

Monitoring throughout comprised electrocardiography, pulse oximetry, non-invasive blood pressure measurement and capnography. Positioning was supine, lateral or prone according to surgical requirement. Tube depth at the incisor was noted immediately after securement and measured again once surgery had finished.

2.4. Exposure variable

Exposure was defined as the actual operative duration in minutes, timed from induction of anaesthesia to the end of the surgical procedure. It entered the regression models as a continuous variable expressed in 30-minute units, so that the odds ratio produced would carry a directly interpretable clinical meaning, and was additionally grouped for descriptive and trend purposes into three bands specified in advance: 60 minutes or less, 61 to 120 minutes, and more than 120 minutes. These boundaries were selected to mirror the short, intermediate and prolonged elective cases encountered in ordinary list planning, and to sit alongside the 60-minute threshold that recurs in the perioperative ocular-injury literature [22].

2.5. Definition of outcomes

The attending anaesthesiologist assessed four intraoperative endpoints. Displacement was recorded when tube depth at the incisor had altered by more than 1 cm between the measurement taken after securement and that taken at the close of surgery. Peri-oral soft-tissue injury covered any newly apparent abnormality of lip or oral mucosa noted at the end of the case, described qualitatively as lip erythema, mucosal abrasion, lip swelling, lip indentation, generalised erythema or mucosal erythema. Bite-related obstruction denoted any occlusion of the tube attributable to the patient biting. Ocular complication meant conjunctival redness or ocular irritation appearing at emergence.

A composite endpoint, specified before analysis, was met when a patient sustained one or more of these four events. The rationale for compositing was twofold: individual events were expected to be infrequent, so that a composite affords greater efficiency in detecting an effect of duration; and the four share a coherent mechanistic origin, all arising from prolonged mechanical contact between airway apparatus and peri-oral or periocular tissue.

Two outcomes were reported by patients themselves. Discomfort was rated on a 10-point visual analogue scale (VAS) and classified as mild for scores of 1 to 3 or moderate for scores of 4 to 6; no patient scored in the severe range of 7 to 10. Satisfaction was captured on a two-level ordinal scale as satisfied or very satisfied. Modelling used the dichotomies moderate versus mild discomfort and very satisfied versus satisfied.

2.6. Statistical methods

Data were entered in Microsoft Excel and analysed in IBM SPSS Statistics for Windows version 26.0 (IBM Corp., Armonk, NY, USA), with confirmatory computation performed in Python 3.11 using SciPy 1.17. Distributional assumptions were checked by the Kolmogorov–Smirnov and Shapiro–Wilk tests. Continuous data appear as mean ± standard deviation, supplemented by median and interquartile range where skew was evident; categorical data appear as counts with percentages and exact binomial 95% confidence intervals.

Operative duration in patients with and without each endpoint was compared using the independent-samples t test with Welch correction alongside the Mann–Whitney U test; because event counts for the individual endpoints were small, the non-parametric result is treated as primary throughout. Frequencies across the three duration bands were examined by Pearson chi-square test, and monotonic dose–response was tested formally with the Cochran–Armitage trend statistic. Spearman rank correlation related duration to the per-patient count of morbidity events and to the ordinal discomfort and satisfaction scales.

How well duration discriminated the composite endpoint and moderate discomfort was quantified by ROC analysis, the area under the curve and its 95% confidence interval being derived by the method of Hanley and McNeil; the Youden index identified the optimal threshold, and sensitivity, specificity and the corresponding odds ratio were calculated at clinically rounded cut-points.

Binary logistic regression established whether duration retained an independent association once other factors were accounted for. Covariates were nominated a priori on clinical grounds — duration per 30 minutes, age per decade, male sex and ASA physical status II — and were entered together; with 26 events available for the

discomfort model this equates to roughly 6.5 events per variable. Fit was judged by the likelihood-ratio chi-square statistic and McFadden pseudo-R^2. Effects are expressed as odds ratios with Wald 95% confidence intervals. Significance was set at a two-sided p below 0.05. Since the individual morbidity endpoints were exploratory, no correction for multiple testing was applied and those p values are best read as hypothesis-generating.

3. Results

3.1. Characteristics of the cohort

All 60 patients recruited completed the study; nobody was lost to follow-up and no value was missing for any variable analysed. Mean age was 38.37 ± 12.60 years, with a range of 18 to 60; 31 patients (51.7%) were men and 38 (63.3%) carried an ASA grade of I. Operations averaged 101.50 ± 42.61 minutes, the median being 95 minutes (IQR 68–140; range 20–180). Fifteen patients (25.0%) fell into the shortest band, 27 (45.0%) into the intermediate band and 18 (30.0%) exceeded 120 minutes.

Table 1 sets out baseline characteristics band by band. Neither age nor sex distribution differed significantly across the three groups (p = 0.562 and p = 0.082). ASA status behaved quite differently: 80.0% and 81.5% of patients in the two shorter bands were graded ASA I, against only 22.2% of those whose surgery ran beyond 120 minutes (p < 0.001). Longer operations being undertaken in patients carrying more comorbidity is exactly what one would expect from ordinary practice, and it was the main reason ASA status was retained in the adjusted models.

Table 1. Baseline characteristics of the cohort, overall and by operative-duration band (n = 60).

Characteristic	Overall (n = 60)	≤60 min (n = 15)	61–120 min (n = 27)	>120 min (n = 18)	p value
Age, years (mean ± SD)	38.37 ± 12.60	38.47 ± 10.68	36.67 ± 13.17	40.83 ± 13.43	0.562
Age group, n (%)					—
18–30 years	18 (30.0)	—	—	—	
31–40 years	12 (20.0)	—	—	—	
41–50 years	18 (30.0)	—	—	—	
51–60 years	12 (20.0)	—	—	—	
Male sex, n (%)	31 (51.7)	7 (46.7)	18 (66.7)	6 (33.3)	0.082
ASA I, n (%)	38 (63.3)	12 (80.0)	22 (81.5)	4 (22.2)	<0.001
ASA II, n (%)	22 (36.7)	3 (20.0)	5 (18.5)	14 (77.8)	
Operative duration, min (mean ± SD)	101.50 ± 42.61	49.33 ± 11.47	94.44 ± 14.76	155.56 ± 16.88	<0.001
Operative duration, min (median, IQR)	95 (68–140)	50 (40–60)	90 (85–105)	160 (140–170)	—

SD, standard deviation; IQR, interquartile range; ASA, American Society of Anesthesiologists physical status. p values derive from one-way analysis of variance for age and duration and from the Pearson chi-square test for sex and ASA.

3.2. Frequency of airway, peri-oral and patient-reported endpoints

Individual events were infrequent, as would be anticipated where securement is standardised and conditions are elective (Table 2). Tube depth shifted by more than 1 cm in 4 patients (6.7%, 95% CI 1.8–16.2); peri-oral soft-tissue injury appeared in 7 (11.7%, 95% CI 4.8–22.6); the tube was occluded by biting in 3 (5.0%, 95% CI 1.0–13.9); and an ocular complication arose in 3 (5.0%, 95% CI 1.0–13.9). Peri-oral injuries were uniformly minor and resolved without intervention, consisting of lip erythema in 2 patients together with one instance each of mucosal abrasion, lip swelling, lip indentation, generalised erythema and mucosal erythema. The ocular events comprised mild conjunctival redness in 2 patients and mild irritation in 1; corneal abrasion was not encountered. Seventeen patients (28.3%, 95% CI 17.5–41.4) met the composite endpoint, and none accrued more than a single component.

Discomfort afterwards was mild in 34 patients (56.7%) and moderate in 26 (43.3%), with nobody reporting severe discomfort. Thirty-two patients (53.3%) declared themselves satisfied and 28 (46.7%) very satisfied.

Table 2. Frequency of intraoperative airway and peri-oral events and of patient-reported outcomes (n = 60).

Outcome	n	%	95% CI (%)
Tube displacement >1 cm	4	6.7	1.8–16.2
Peri-oral soft-tissue injury	7	11.7	4.8–22.6
Bite-related tube obstruction	3	5.0	1.0–13.9
Ocular complication	3	5.0	1.0–13.9
Composite airway/peri-oral event	**17**	**28.3**	**17.5–41.4**
Moderate postoperative discomfort	26	43.3	30.6–56.8
Severe postoperative discomfort	0	0.0	0.0–6.0
Very satisfied	28	46.7	33.7–60.0

CI, confidence interval (exact binomial). The composite endpoint is met by any of tube displacement, peri-oral soft-tissue injury, bite-related tube obstruction or ocular complication.

3.3. Operative duration in relation to airway morbidity

Patients who met the composite endpoint had spent appreciably longer in theatre than those who did not (118.82 ± 42.34 against 94.65 ± 41.21 minutes; Mann–Whitney U p = 0.041; Welch t test p = 0.054). Nowhere was the association sharper than for displacement: the four patients whose tube migrated beyond 1 cm had a mean operative time of 170.00 ± 11.55 minutes, compared with 96.61 ± 39.68 minutes among those whose tube held position (p = 0.002), and each of these four operations lasted at least 160 minutes. Ocular complications behaved similarly, all three arising between 130 and 140 minutes (136.67 ± 5.77 versus 99.65 ± 42.92 minutes), though with only three events the non-parametric comparison fell short of significance (p = 0.139).

Peri-oral soft-tissue injury conspicuously failed to follow the gradient (104.29 ± 25.40 versus 101.13 ± 44.55 minutes; p = 0.695), and bite-related obstruction ran weakly in the opposite direction (66.67 ± 40.41 versus 103.33 ± 42.26 minutes; p = 0.185), one of its three episodes occurring during a case lasting just 20 minutes. Across the cohort, the number of morbidity events a patient accrued rose with duration (Spearman ρ = 0.267, p = 0.039). Table 3 gives the full set of comparisons.

Table 3. Operative duration according to the presence or absence of each outcome.

Outcome	Present mean ± SD (min)	Absent mean ± SD (min)	t test p	Mann–Whitney p
Tube displacement (n = 4)	170.00 ± 11.55	96.61 ± 39.68	<0.001	0.002
Peri-oral injury (n = 7)	104.29 ± 25.40	101.13 ± 44.55	0.787	0.695
Bite obstruction (n = 3)	66.67 ± 40.41	103.33 ± 42.26	0.253	0.185
Ocular complication (n = 3)	136.67 ± 5.77	99.65 ± 42.92	<0.001	0.139
Composite event (n = 17)	118.82 ± 42.34	94.65 ± 41.21	0.054	0.041
Moderate discomfort (n = 26)	128.85 ± 40.18	80.59 ± 31.35	<0.001	<0.001
Very satisfied (n = 28)	79.29 ± 32.91	120.94 ± 40.95	<0.001	<0.001

SD, standard deviation. The t test shown is the independent-samples test with Welch correction for unequal variances. Given how few events occurred for the individual endpoints, the Mann–Whitney U test is regarded as the primary comparison.

3.4. Dose–response across duration bands

Stratifying by duration revealed a graded pattern for the composite endpoint, which rose from 6.7% in operations of 60 minutes or less, through 29.6% in the 61-to-120-minute band, to 44.4% beyond 120 minutes (Cochran–Armitage trend p = 0.017). Displacement and ocular complication were restricted entirely to the longest band, occurring in 22.2% and 16.7% respectively (trend p = 0.008 and p = 0.023). Neither peri-oral injury nor bite obstruction described a monotonic course (p = 0.724 and p = 0.357).

Steepest of all was the gradient for postoperative discomfort, which climbed from 6.7% to 37.0% and then to 83.3% across the three bands (trend p < 0.001); the proportion awarding the highest satisfaction rating fell

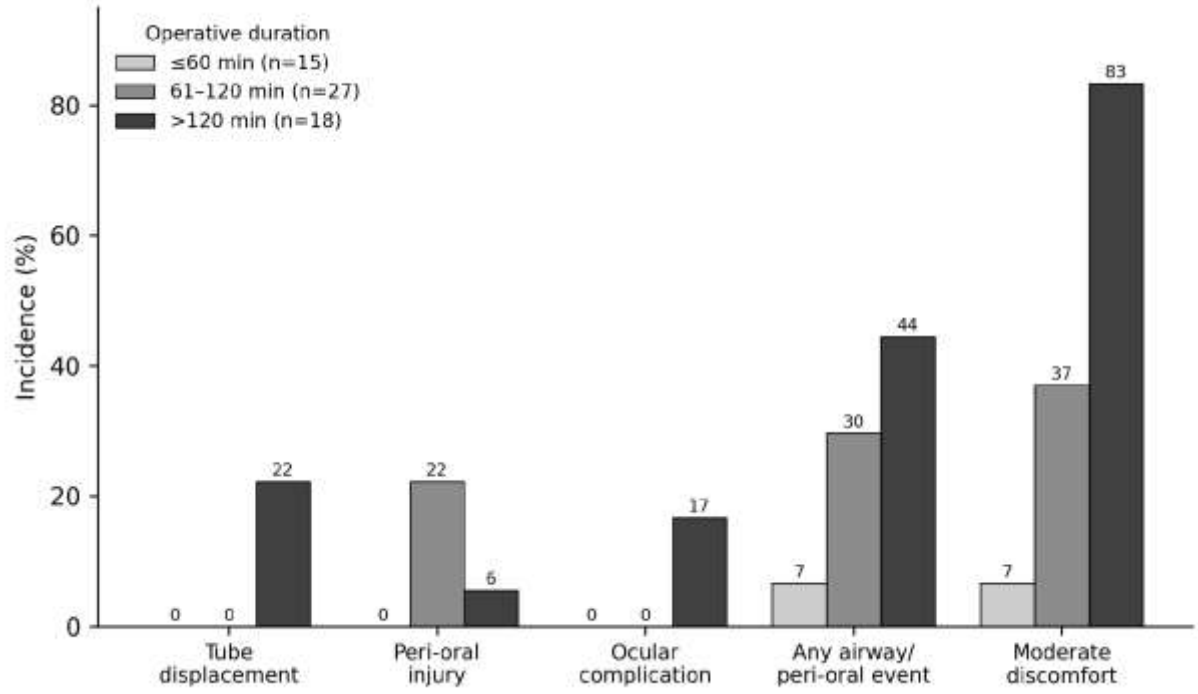
correspondingly from 80.0% to 48.1% to 16.7% (trend p < 0.001). Table 4 summarises these relationships and Figure 1 displays them.

Table 4. Outcome frequency across operative-duration bands, with test for trend.

Outcome, n (%)	≤60 min (n = 15)	61–120 min (n = 27)	>120 min (n = 18)	χ^2 p	Trend p
Tube displacement	0 (0.0)	0 (0.0)	4 (22.2)	0.007	0.008
Peri-oral injury	0 (0.0)	6 (22.2)	1 (5.6)	0.062	0.724
Bite obstruction	1 (6.7)	2 (7.4)	0 (0.0)	0.506	0.357
Ocular complication	0 (0.0)	0 (0.0)	3 (16.7)	0.025	0.023
Composite event	1 (6.7)	8 (29.6)	8 (44.4)	0.055	0.017
Moderate discomfort	1 (6.7)	10 (37.0)	15 (83.3)	<0.001	<0.001
Very satisfied	12 (80.0)	13 (48.1)	3 (16.7)	0.001	<0.001

χ^2, Pearson chi-square test across the three bands; Trend, Cochran–Armitage test for linear trend in proportions.

Figure 1. Incidence of intraoperative and patient-reported outcomes across operative-duration bands.



Each bar gives the percentage of patients within a duration band who experienced the outcome concerned. Tube displacement and ocular complication were confined to operations exceeding 120 minutes. Cochran–Armitage trend p values: composite event 0.017; moderate discomfort <0.001; tube displacement 0.008; ocular complication 0.023.

3.5. Independent predictors of discomfort and satisfaction

On univariable regression, every extra half-hour in theatre almost trebled the odds of moderate discomfort (OR 2.88, 95% CI 1.67–4.98; p < 0.001). ASA grade II likewise appeared associated with moderate discomfort before adjustment, affecting 68.2% of ASA II patients against 28.9% of ASA I patients (Fisher p = 0.006), whereas sex bore no relation to it (p = 0.603).

When age, sex and ASA status were adjusted for simultaneously, operative duration stood alone as an independent predictor of moderate discomfort, carrying an adjusted odds ratio of 2.77 for each additional 30 minutes (95% CI 1.41–5.44; p = 0.003). The apparent contribution of ASA grade dissolved completely upon adjustment (adjusted OR 1.28, 95% CI 0.14–11.57; p = 0.826) — a pattern consistent with confounding by indication, since the ASA II patients in this cohort were disproportionately those whose operations ran longest.

Overall the model was strongly significant (likelihood-ratio $\chi^2 = 22.53$, $p < 0.001$) and accounted for a considerable share of outcome variance (McFadden pseudo-$R^2 = 0.274$). Table 5 presents the results.
Satisfaction reproduced the same pattern with the sign reversed. Each further 30 minutes roughly halved the odds that a patient would award the top satisfaction rating (adjusted OR 0.49, 95% CI 0.26–0.91; p = 0.024), while age, sex and ASA status contributed nothing independently (Table 6; likelihood-ratio $\chi^2 = 23.15$, $p < 0.001$; pseudo-$R^2 = 0.279$). For the composite morbidity endpoint the effect pointed the same way but did not attain conventional significance after adjustment (adjusted OR 1.66 per 30 minutes, 95% CI 0.92–3.00; p = 0.093), a reflection of how few events were available.

Table 5. Univariable and multivariable logistic regression for moderate postoperative discomfort (n = 60; 26 events).

Predictor	Unadjusted OR (95% CI)	p	Adjusted OR (95% CI)	p	β
Operative duration, per 30 min	**2.88 (1.67–4.98)**	**<0.001**	**2.77 (1.41–5.44)**	**0.003**	**1.019**
Age, per 10 years	—	0.251	1.19 (0.54–2.62)	0.676	0.169
Male sex	—	0.603	1.19 (0.28–5.04)	0.813	0.175
ASA physical status II	—	0.006	1.28 (0.14–11.57)	0.826	0.247

OR, odds ratio; CI, confidence interval; ASA, American Society of Anesthesiologists. Unadjusted p values for age and sex come from the t test and Fisher exact test respectively. Multivariable model: likelihood-ratio $\chi^2 = 22.53$, $p < 0.001$; McFadden pseudo-$R^2 = 0.274$.

Table 6. Multivariable logistic regression for the highest level of patient satisfaction (n = 60; 28 events).

Predictor	Adjusted OR (95% CI)	p	β
Operative duration, per 30 min	**0.49 (0.26–0.91)**	**0.024**	**−0.712**
Age, per 10 years	0.88 (0.40–1.93)	0.746	−0.130
Male sex	0.65 (0.15–2.76)	0.558	−0.433
ASA physical status II	0.20 (0.02–1.73)	0.142	−1.629

Model: likelihood-ratio $\chi^2 = 23.15$, $p < 0.001$; McFadden pseudo-$R^2 = 0.279$. Odds ratios below unity denote reduced odds of awarding the highest satisfaction rating.

3.6. Discrimination and candidate thresholds

Operative duration discriminated moderate discomfort well, generating an area under the ROC curve of 0.824 (95% CI 0.712–0.935; p < 0.001). For the composite morbidity endpoint discrimination was more modest, though still statistically significant, at 0.671 (95% CI 0.512–0.830; p = 0.035). Both curves appear in Figure 2.
The Youden index placed the optimal threshold for moderate discomfort at 80 minutes, where sensitivity reached 96.2% and specificity 58.8%, equating to an odds ratio of 35.7 (Fisher p < 0.001); applied to the composite endpoint the same threshold gave 94.1% sensitivity and an odds ratio of 13.9 (p = 0.003). Pushing the threshold out to 100 minutes lifted specificity to 76.5% but cost sensitivity, which fell to 65.4%. Near-complete sensitivity at 80 minutes tells us that discomfort beyond mild intensity was virtually never met in shorter cases: of the 21 patients whose surgery lasted 80 minutes or less, only 1 reported moderate discomfort. Table 7 details performance at each threshold.

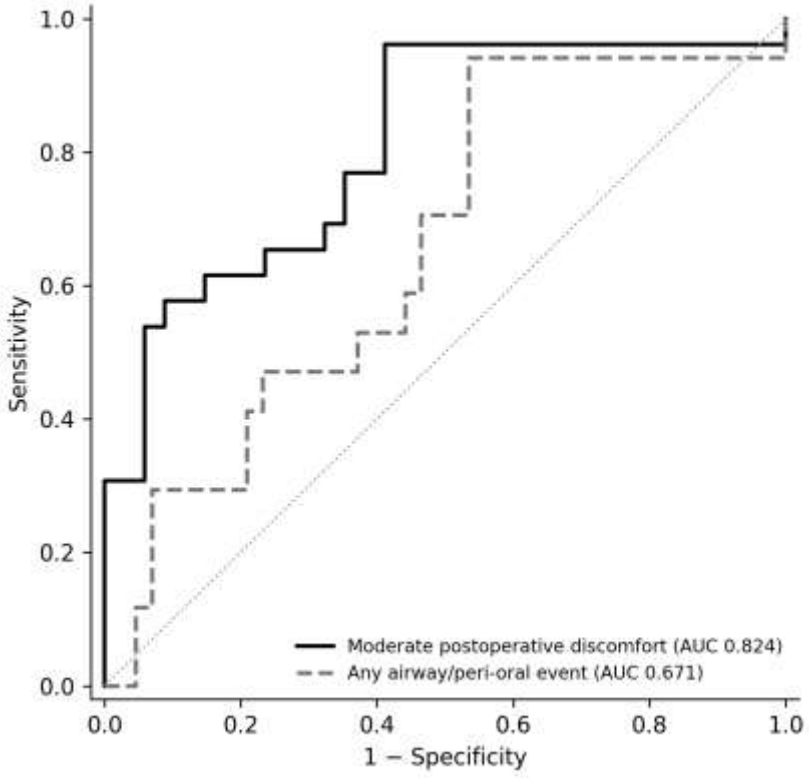
Table 7. Discriminative performance of operative duration for moderate postoperative discomfort and for the composite airway/peri-oral endpoint.

Endpoint / threshold	AUC (95% CI)	Sensitivity (%)	Specificity (%)	OR	p
Moderate discomfort	0.824 (0.712–0.935)	—	—	—	<0.001
>80 min (Youden optimal)	—	96.2	58.8	35.7	<0.001
>90 min	—	76.9	64.7	6.11	0.002
>100 min	—	65.4	76.5	6.14	0.002

Endpoint / threshold	AUC (95% CI)	Sensitivity (%)	Specificity (%)	OR	p
Composite event	0.671 (0.512–0.830)	—	—	—	0.035
>80 min (Youden optimal)	—	94.1	46.5	13.9	0.003
>90 min	—	70.6	53.5	2.76	0.150

AUC, area under the receiver-operating-characteristic curve with Hanley–McNeil 95% CI; OR, odds ratio; threshold-specific p values from the Fisher exact test.

Figure 2. Receiver-operating-characteristic curves for operative duration as a predictor of moderate postoperative discomfort and of the composite airway/peri-oral endpoint.

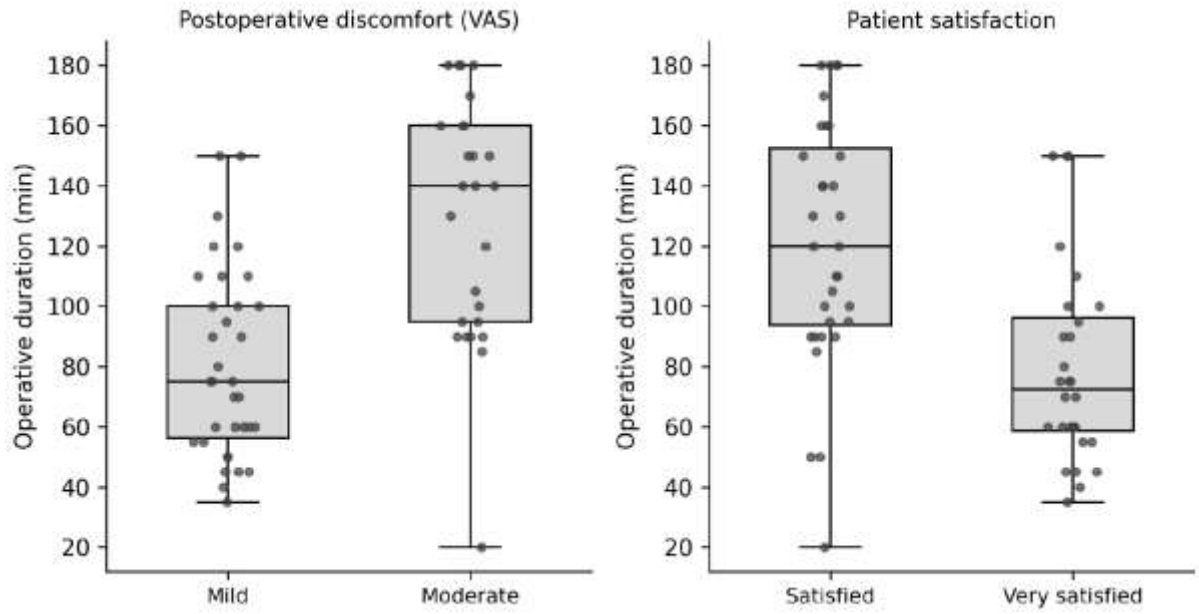


Duration discriminated moderate postoperative discomfort with an area under the curve of 0.824 (95% CI 0.712–0.935) and the composite airway/peri-oral endpoint with an area under the curve of 0.671 (95% CI 0.512–0.830). The diagonal reference line represents no discrimination.

3.7. How morbidity, discomfort and satisfaction relate to one another

The intraoperative and patient-reported domains proved closely interlocked. Of the 17 patients who met the composite endpoint, 16 rated their discomfort as moderate rather than mild — 94.1%, against 23.3% among those spared an event (Fisher $p < 0.001$) — and every one of the 7 patients with peri-oral injury and all 4 with tube displacement sat in the moderate-discomfort group. Satisfaction shadowed discomfort almost deterministically: 27 of the 28 patients awarding the top rating had experienced only mild discomfort, whereas 25 of the 32 giving the lower rating had reported moderate discomfort ($p < 0.001$). Not a single patient who sustained a composite event gave the highest satisfaction rating (0 of 17, against 28 of 43; $p < 0.001$). Figure 3 shows how operative duration was distributed by discomfort and satisfaction category.

Figure 3. Distribution of operative duration by category of postoperative discomfort and of patient satisfaction.



Boxes show the median and interquartile range, with individual patient values overlaid. Mean operative duration was 128.85 ± 40.18 minutes in those reporting moderate discomfort against 80.59 ± 31.35 minutes in those reporting mild discomfort ($p < 0.001$), and 79.29 ± 32.91 minutes in those awarding the highest satisfaction rating against 120.94 ± 40.95 minutes in the remainder ($p < 0.001$).

4. Discussion

Within a cohort deliberately constructed so that endotracheal tube securement did not vary between patients, the length of the operation proved to be the principal driver of airway and peri-oral morbidity and the only factor independently predicting postoperative discomfort and satisfaction. Every extra 30 minutes of operating time raised the odds of moderate discomfort roughly 2.8-fold and halved the odds of the highest satisfaction rating, with age, sex and physical status all accounted for. Composite morbidity mounted steadily across duration bands, and the two endpoints with the clearest mechanical underpinning — tube displacement and ocular complication — occurred solely in operations running past 120 minutes.

What gives this design its value is what it takes away. In most cohorts investigating airway morbidity, fixation technique varies between patients and is itself bound up with anticipated case complexity and expected length, so that an effect of duration and an effect of securement cannot be told apart. Fixing securement across the cohort closes that route. The gradient that remains cannot be explained by some patients having been taped less securely than others; it belongs to time, and to the mechanical and physiological processes that accrue with it.

4.1. Relation to existing evidence

Our discomfort findings sit comfortably beside the postoperative sore throat literature, where duration of anaesthesia ranks among the most reliably replicated risk factors. In a multicentre prospective cohort of 152 intubated adults, Bekele and Melese calculated an adjusted odds ratio of 4.5 (95% CI 1.66–12.18) for prolonged anaesthesia, together with effects attributable to tube size and to age [18]. Gemechu and colleagues arrived at much the same conclusion regarding anaesthetic duration in a cross-sectional series of 240 patients [19], as has a meta-analysis of sore-throat incidence worldwide [20]. Allowing for the different units in which exposure was expressed, our adjusted figure of 2.77 per 30 minutes is of comparable magnitude. Worth noting is that the ASA effect visible in our univariable analysis vanished altogether once duration was adjusted for, which raises the possibility that in some published series the apparent role of comorbidity in airway discomfort partly reflects unmeasured confounding by operating time.

The ocular result accords with a substantial literature linking prolonged surgery to perioperative corneal injury. Analyses of voluntary incident-reporting databases have singled out procedures beyond 60 minutes as a recurring characteristic of reported abrasions [22], and case-control work has put the adjusted odds at roughly 4.6-fold for operations of three hours or more [23]. Our three ocular events all fell between 130 and 140 minutes, an interval consistent with those observations; that they amounted to no more than mild conjunctival redness

and irritation, with corneal abrasion absent throughout, is plausibly explained by the fixed eye shield that every patient received [21].

The displacement finding warrants particular emphasis. Comparative studies of tape against commercial holders — among them a randomised trial in critically ill adults and a recent systematic review with meta-analysis — have concentrated on which device better resists displacement [10,11]. Our data point to a complementary question that has gone largely unasked: for how long does any given method of securement retain its hold? Every displacement in our cohort occurred at 160 minutes or beyond, none earlier, in a population where the securing device was identical throughout. Such a pattern fits progressive time-dependent deterioration of the interface between tube, device and patient — through accumulating secretions, repeated repositioning and cumulative traction along the circuit — considerably better than it fits an intrinsic failure rate spread evenly across cases [15,16].

That peri-oral injury and bite obstruction behaved differently is informative rather than anomalous. Peri-oral injuries clustered in the middle band and traced no trend, while one bite obstruction arose in a case lasting only 20 minutes. Both endpoints arguably hinge on the mechanics of a single moment — the force and geometry applied during laryngoscopy, and the timing and depth of emergence relative to neuromuscular recovery — rather than on cumulative exposure. The fact that duration predicted the time-dependent endpoints while leaving the event-dependent ones untouched is internally coherent, and argues against the alternative explanation that longer cases simply attract closer scrutiny.

4.2. Implications for practice

Operative duration is written into every anaesthetic record and is available minute by minute without any additional measurement, yet it is rarely put to prospective use as a cue for reassessing the airway. Our data support treating elapsed time as something to act upon rather than something to describe afterwards. Two thresholds emerge. The Youden-optimal cut-point of 80 minutes captured 96.2% of patients who went on to report moderate discomfort, which makes it a defensible point at which to begin scheduled reassessment — re-checking tube depth at the incisor, inspecting where the device meets the lip, confirming that ocular protection remains intact — while accepting that many such checks will find nothing amiss. The 120-minute mark is where the more consequential events in this cohort started to appear, and where reassessment shifts from sensible to obligatory.

Viewed from the patient's side, the satisfaction data drive the same point home. Nobody who sustained an airway or peri-oral event awarded the highest satisfaction rating, and satisfaction tracked discomfort almost perfectly. Minor peri-oral and periocular morbidity is easy for clinicians to dismiss as trivial when their attention is fixed on weightier endpoints, yet it is exactly the sort of outcome patients notice and remember. Measures aimed at long cases — repositioning the device periodically, topping up ocular lubrication, keeping an eye on cuff pressure as the hours pass — cost little and might well repay the effort, and deserve prospective testing.

4.3. Strengths and limitations

This analysis draws its main strength from having removed fixation technique as a confounder by applying one securement device to the whole cohort, which permits the effect of duration to be estimated with less residual confounding than is usually achievable. Prospective collection with complete follow-up and no missing values, covariates nominated in advance, and formal testing for dose–response further support internal validity.

Several limitations must be conceded. To begin with, 60 patients yielded very few events for the individual endpoints; the estimates for displacement, ocular complication and bite obstruction rest on three or four events apiece and carry correspondingly wide confidence intervals. The composite endpoint mitigates this constraint without abolishing it, and the adjusted estimate for the composite did not achieve conventional significance. Secondly, this is observational work from a single centre in which duration was not randomly allocated; longer operations differ systematically from shorter ones in complexity, positioning, fluid shifts and patient comorbidity. Although age, sex and ASA status were adjusted for, residual confounding by surgical category, patient position and endotracheal tube calibre — none of which the dataset captured — cannot be ruled out, and tube size in particular is a recognised determinant of airway discomfort [18,20]. Thirdly, discomfort and satisfaction were recorded on coarse instruments, the former reduced to mild versus moderate and the latter to two levels; finer scales with repeated postoperative measurement, as employed in the sore-throat literature, would allow the trajectory of severity to be described rather than merely its presence. Fourthly, outcomes were ascertained by the attending anaesthesiologist without blinding to duration, which admits the possibility of assessment bias; the contrasting behaviour of time-dependent and event-dependent endpoints argues against a straightforward surveillance effect but does not exclude one. Fifthly, recruitment was confined to ASA I–II adults aged 18 to 60 undergoing elective surgery, so the findings cannot be extended to emergency work, to elderly or substantially comorbid patients, or to operations running well beyond three hours — the very interval in which the ocular literature suggests risk rises most steeply [23]. Finally, the parent protocol was registered

after recruitment had begun, and although every variable analysed here was gathered prospectively under the original data-collection instrument, this secondary analysis was not itself pre-registered and should be read as hypothesis-generating.

4.4. Future directions

The obvious next step is a larger multicentre cohort with enough events to model the individual endpoints rather than a composite, incorporating tube calibre, serially recorded cuff pressure, patient position and surgical category. Measuring tube depth serially instead of only at the end of the case would show at what point during a long operation displacement actually develops — precisely the information needed to set a reassessment interval on empirical rather than pragmatic grounds. Ultimately the hypothesis generated here, that scheduled airway reassessment at defined intervals lowers peri-oral, periocular and discomfort outcomes in prolonged surgery, is testable in a randomised comparison of protocolised time-triggered reassessment against usual care.

5. Conclusion

Where the method of securing the endotracheal tube is held constant throughout a cohort, the length of the operation emerges as a dose-related determinant of airway and peri-oral morbidity and as the sole independent predictor of postoperative discomfort and patient satisfaction. Not one tube displacement and not one ocular complication occurred before 120 minutes had elapsed, and each further 30 minutes of operating time nearly trebled the odds of moderate discomfort while halving the odds of the highest satisfaction rating. Elapsed operative time is available universally and at no cost; it merits handling as a modifiable risk exposure that should trigger deliberate airway reassessment somewhere past the 80- to 120-minute mark, rather than being noted passively once the case is over.

Declarations

Ethics approval and consent to participate. Approved by the Institutional Human Ethics Committee, Saveetha Medical College and Hospital, SIMATS, Chennai (014/01/2026/IEC/SMCH). Written informed consent was obtained from every participant. The parent protocol carries Clinical Trials Registry – India registration CTRI/2026/02/103521; registration was completed after recruitment had commenced, and this is disclosed in the interest of transparency.

Consent for publication. Not applicable; no individually identifiable patient data appear in this report.

Availability of data and materials. The de-identified dataset underlying this analysis may be obtained from the corresponding author on reasonable request.

Competing interests. The investigators participated in developing the endotracheal tube stabilisation device used to standardise securement in this cohort. The present analysis concerns operative duration as an exposure and does not assess device performance against any comparator; the involvement is nonetheless disclosed in full.

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Authors' contributions. [Author 1] conceived the analysis, collected the data and prepared the draft. [Author 2] contributed to design and to interpretation of the findings. [Author 3] supervised the project, revised the manuscript critically and approved the version submitted. All authors have read and approved the final manuscript and accept accountability for all aspects of the work.

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