

# Pupil Size Changes as an Objective Indicator of Sedation Depth and Behavior

Bhagal, J, Chapman, M

## INTRODUCTION:

Managing pediatric patient behavior during dental procedures is essential for safety and treatment success. Traditionally, clinicians rely on subjective scales like the Frankl Behavior Rating Scale to gauge cooperation.<sup>1</sup> While useful, these assessments can vary between providers and lack real-time physiological feedback. Sedation is commonly employed to reduce anxiety and improve compliance, but monitoring its depth and behavioral impact remains challenging. Pupil size, a well-established autonomic marker, reflects changes in arousal and sedation levels.<sup>3</sup> Pupil dynamics may also correlate with behavioral responses, offering a potential objective biomarker for predicting cooperation. By examining the relationship among sedation level, pupil size, and Frankl score, we aim to determine whether a simple physiological measure can enhance behavioral prediction and guide clinical decision-making.

## METHODS:

Thirty-two children (ages 4-11) received oral sedation with morphine (0.5mg/kg) and Atarax (25mg) for dental treatment. Photo consent was obtained by a parent or guardian. Two pupil photographs were taken: one prior to sedation and another 30–63 minutes (mean time) after medication administration, just prior to nitrous oxide delivery and treatment initiation (Figure 1). An additional provider monitored the patient during the sedation and recorded sedation depth every 5 minutes using the UMSS sedation grading scale.<sup>2</sup> Behavior was recorded using the Frankl Behavior Rating Scale.<sup>1</sup> The irises and pupils were measured for each eye, pre-operatively and prior to beginning treatment, using Microsoft PowerPoint, and a ratio for the pupil/iris size was calculated. Mean sedation level across the procedure was computed for each patient. A regression analysis was used to examine the relationship between sedation level and pupil size change (n = 31). ANOVA test was used to compare pupil size across Frankl score groups to assess behavioral correlation. One outlier was excluded from the analysis.

## RESULTS:

A total of 31 pediatric patients were included in the study (55% females, 45% males). An increased depth of sedation was significantly associated with larger changes in pupil size ( $\beta = 0.222, p = 0.034$ ). Changes in pupil size also differed significantly across Frankl behavior groups ( $p = 0.027$ ). Patients exhibiting a larger delta in miosis demonstrated higher Frankl scores, suggesting better cooperation for treatment (Figures 2 & 3).



Figure 1: Pre-op photo taken (left) compared to photo taken after medication administration (right).

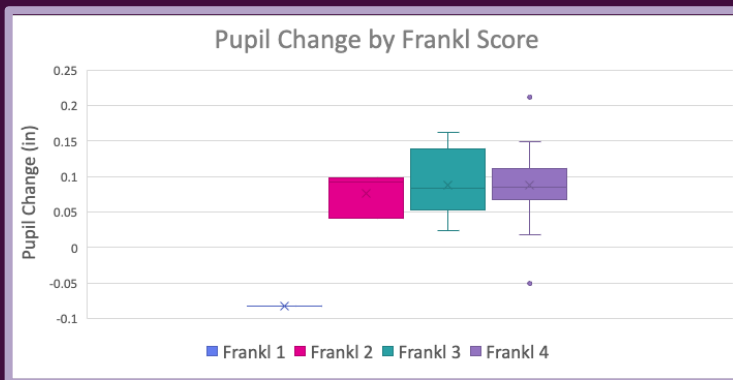


Figure 2: Box-and-whisker plot showing the change in pupil size (measured in inches) for each Frankl behavior score group.

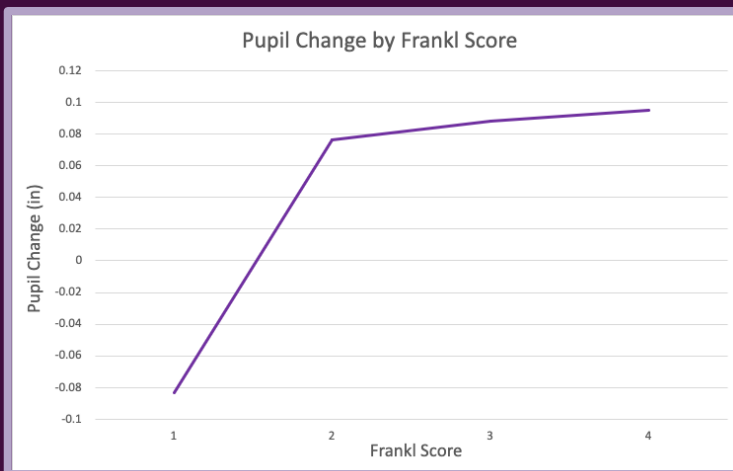


Figure 3: Regression analysis showing the relationship between change in pupil size (measured in inches) and Frankl behavior score.

## DISCUSSION:

The observed association between larger pupil size changes and higher Frankl scores suggests that pupil size may serve as an objective biomarker for both sedation depth and behavioral response. While the effect size is modest, the findings support further exploration of pupillometry as a predictive tool for patient management.

Although the group means are close, the ANOVA indicates that Frankl score is associated with a significant difference in pupil size. Patients who exhibit greater changes in pupil size tend to fall into groups with higher Frankl scores, suggesting that physiological indicators like pupil constriction may correlate with more positive behavioral responses during treatment. Interpretation of these findings should consider the sample size, potential variability to pupil measurement, and the subjective nature of assigning a Frankl behavioral assessment score. Nevertheless, the observed differences suggest that pupil size may serve as a useful objective adjunct to behavioral scoring to enhance clinical decision-making in a pediatric dental sedation setting.

## CONCLUSION:

These findings suggest that pupil size may serve as a simple, objective biomarker for both sedation depth and behavioral response. Using an autonomic measurement like pupil size, offers a consistent value to predict behavioral response and guide clinical decision-making during pediatric sedations. The results support further investigation of pupil size as a complementary tool to enhance patient management.

## REFERENCES:

1. American Academy of Pediatric Dentistry. Behavior guidance for the pediatric dental patient. The Referenxqce Manual of Pediatric Dentistry. Chicago, IL: American Academy of Pediatric Dentistry; 2025:379-99.
2. Malviya, S., Voepel-Lewis, T., Tait, A. R., Merkel, S., Tremper, K., & Naughton, N. (2002). Depth of sedation in children undergoing computed tomography: validity and reliability of the University of Michigan Sedation Scale (UMSS). *British journal of anaesthesia*, 88(2), 241–245. <https://doi.org/10.1093/bja/88.2.241>
3. Tosi, F., Gatto, A., Capossela, L., Ferretti, S., Mancino, A., Curatola, A., Chiaretti, A., & Pulitanò, S. (2021). Role of the pupillometer in the assessment of pain in the sedation of pediatric patients. *European review for medical and pharmacological sciences*, 25(20), 6349–6355. <https://doi.org/10.26355/eurerv.202110.27008>