• Clinical Research •

Different techniques for a safe long stump during enucleation for retinoblastoma patients

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Abstract

• **AIM:** To compare the surgical outcomes of different surgical techniques of globe handling and optic nerve transection in enucleation for retinoblastoma.

• **METHODS:** A randomized controlled trial was conducted in patients with Group E retinoblastoma. Patients were assigned to one of the following techniques: assisted globe elevation using a Wells spoon, muscle traction sutures, or haemostat clamp optic nerve traction. The outcomes measured were the length of the optic nerve stump and surgical time required for nerve transection.

• **RESULTS:** The study included 45 retinoblastoma patients with mean age of 21.7±17.1mo (range 4–96mo) and 25 (55.6%) males. The clamp technique achieved the longest mean stump length (13.5±4.5 mm), significantly longer than the Wells spoon (10.4±2.7 mm) and muscle traction suture techniques (6.7±1.8 mm, *P*<0.001). The operative time was shortest with the Wells spoon technique (11.5±2.1min), followed by the clamp (13±3.3min) and muscle traction suture techniques (20.1±3.3min, *P*<0.001), a difference that was more pronounced in challenging cases, such as buphthalmic eyes with enlarged thin-walled globes. Furthermore, the pathological optic nerve stump length was the longest with the haemostat clamp technique (12±4.2 mm), compared to the Wells spoon (9.5±3.1 mm) and muscle traction sutures (5.9±1.7 mm, *P*<0.001).

• **CONCLUSION:** The haemostat clamp technique provides better outcomes in terms of optic nerve stump length with acceptable surgical time, making it the preferred method for enucleation of advanced retinoblastoma. The Wells spoon technique is a viable alternative for less complex cases.

• **KEYWORDS:** retinoblastoma; enucleation; optic nerve stump; extra scleral extension

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INTRODUCTION

Retinoblastoma is the most common intraocular malignancy in childhood, commonly occurring under 4 years of age. If left untreated, it can lead to death within 1–2y[1-2]. Despite major advances in chemo reduction and local treatment of retinoblastoma, enucleation remains the last resort in cases of extensive tumors as a life saving measure[3]. Pathological assessment is crucial in determining high-risk factors for extraocular spread, which include massive choroidal invasion, post laminar optic nerve invasion, scleral invasion, and anterior chamber involvement. If these risk factors are present, adjuvant chemotherapy is recommended to reduce the risk of extraocular relapses[3-5].

One of the basic principles of enucleation under such conditions is to obtain a long segment of the optic nerve to ensure a free surgical margin[6]. Detailed surgical techniques to achieve reproducible long stumps with free margins are scarcely described in the literature. Furthermore, careful handling of retinoblastoma-affected globes requires special attention to avoid globe perforation with an increased risk of tumor cell spilling, especially in high-risk conditions such as buphthalmic eyes[6-7].

Therefore, the aim of our study was to describe our technique using the hemostat traction technique and compare it with different techniques to obtain a safe long optic nerve stump.

PARTICIPANTS AND METHODS

Ethical Approval This study adhered to international ethical standards and tenets of the Declaration of Helsinki. This study was approved by the Ethics Review Committee of Cairo University, Faculty of Medicine with approval IRB# MS-241-2024. An informed written consent for participation in the study has been obtained from all guardians of participants.

Participants This prospective randomized controlled study was designed to compare three different surgical techniques during enucleation in patients with retinoblastoma. The

study included 45 retinoblastoma patients who presented to the Ocular Oncology Unit at Kasr El Aini Cairo University Hospital with Group E (extensive retinoblastoma occupying >50% of the globe with or without neovascular glaucoma, hemorrhage, and extension of the tumor to the optic nerve or anterior chamber according to the International Classification of Retinoblastoma). Patients who had received other treatments for retinoblastoma prior to enucleation, such as radiation therapy or chemotherapy, were excluded.

The patients were randomly divided into 3 groups using an envelope selection: group 1: globe assisted elevation using Wells spoon; group 2: muscle traction sutures; group 3: haemostat clamp traction technique.

All patients underwent full ophthalmological examination together with routine retinoblastoma investigations, including ocular ultrasound to measure the tumour and detect any calcifications. Magnetic resonance imaging (MRI) was also performed using gadolinium enhancement to evaluate any intra- or extraocular extension or intracranial tumour spread.

Surgical Details Under general anesthesia, the operated eye was confirmed *via* an intraoperative fundus examination. Limbal conjunctival 360 degrees peritomy was performed with Wescott scissors, followed by undermining of the underlying Tenon's layer in all quadrants with blunt dissection. Muscle hooking was performed at the beginning of the timer. Muscle transection started with the medial rectus muscle after hooking and securing by a locking double armed 6-0 Vicryl suture posterior to the insertion, leaving a suitable stump of approximately 4 mm. This was followed by suturing the inferior, lateral, and superior recti in a purse-string manner. The superior and inferior oblique muscles were severed without sutures. Anterior luxation of the globe above the orbital rim to free a retrobulbar space for introducing the instruments, with 360-degree globe rotation to ensure complete globe separation from any tethering bands or residual muscle fibers. The optic nerve was identified, and any of the three techniques was performed. In the three techniques, the orbital apex was reached by a long straight slender surgical scissors 145 mm to ensure the longest possible stump.

In Group 1: the globe was elevated using a Wells spoon, where the spoon slid behind the globe and hugged the optic nerve at its insertion into the globe. The globe was drawn anteriorly by lifting the spoon up, straight scissors were introduced through the nasal side parallel to the medial wall, and the nerve was then cut near the orbital apex (Figure 1A, 1B).

In Group 2: two types of sutures were used. Four 4-0 silk sutures for traction on the stump were applied immediately after hooking the muscles posterior to the insertion. Vicryl 6-0 suture was applied as a purse-string suture, as previously described, and the muscles were cut in between. Forward traction of the eyeball was performed using four silk sutures (Figure 1C, 1D), then straight scissors were introduced nasally to transect the optic nerve.

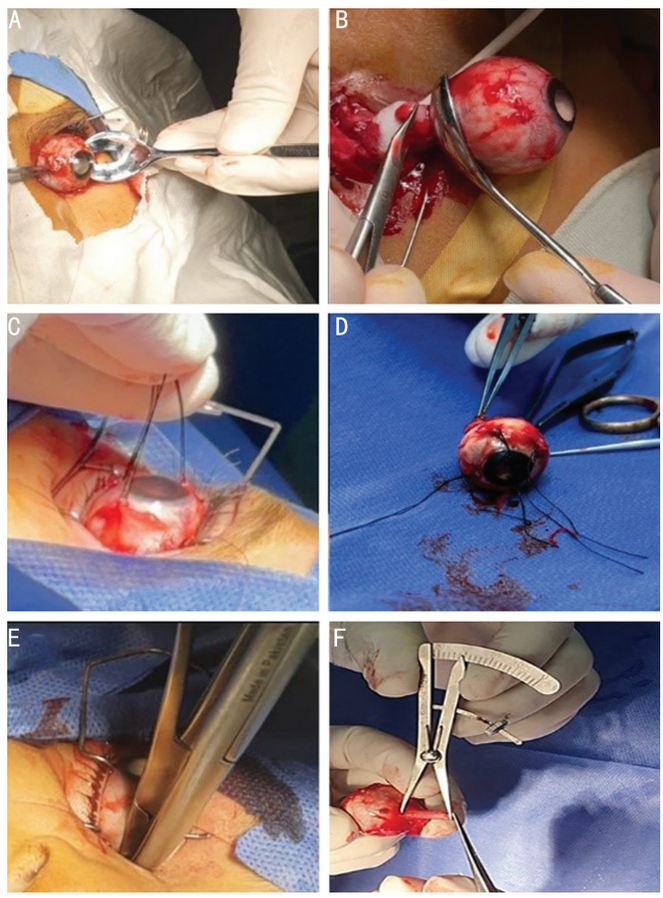


Figure 1 Operative procedure A: Wells spoon sliding behind the eye; B: Wells spoon lifting the globe and scissors cutting the nerve; C: Traction sutures used to lift the globe; D: Enucleated globe with traction sutures; E: Haemostat clamp technique with scissors gliding on its nasal side; F: Intraoperative measurement of the stump (about 15 mm).

In Group 3: a straight slender long hemostat clamp was introduced through a nasal approach parallel to the medial wall until the rope-like feeling of the optic nerve was felt, clamping of the nerve at the maximum length, followed by gentle upward traction, followed by gliding on the surface of the clamp (medial to it) to cut the optic nerve posterior to the clamp near the orbital apex (Figure 1E).

The optic nerve stump was then measured using a caliper intraoperatively (Figure 1F), which was later confirmed by histopathological measurements. Recti muscles were then secured to the implant using preplaced purse-string sutures, and the tenon capsule was then closed with buried absorbable sutures followed by the conjunctiva in the same manner. A conformer was then placed, followed by temporary tarsorrhaphy left for 2wk. Postoperative systemic antibiotics, topical combined antibiotics, and steroids were prescribed. A pressure bandage was applied for 2d to prevent any postoperative hematoma.

The enucleated globe was sent for histopathological assessment of high-risk factors (choroidal invasion, extra scleral extension, or optic nerve involvement) together with the length of the optic nerve and involvement of the surgical stump.

Study Outcomes

Primary outcomes Comparison of different techniques regarding: 1) length of the optic nerve stump (operative and pathological length); 2) surgical time required for nerve transection in each technique.

Secondary outcomes 1) Evaluation of pathological finding of optic nerve stump in different techniques; 2) Any possible complications related to the techniques.

Statistical Analysis Data was collected, tabulated, and statistically analyzed using an IBM-compatible personal computer with the Statistical Package for Social Sciences (SPSS) version 26. Quantitative variables were compared among the three study groups using one way analysis of variance (ANOVA) for normally distributed data or the Kruskal-Wallis test for non-normally distributed data. Categorical variables were compared using the chi-square test or Fisher's exact test, as appropriate. Agreement between the MRI findings and histopathological results was assessed using Cohen's kappa coefficient (κ). A *P*-value of less than 0.05 was considered statistically significant.

RESULTS

Baseline Demographics The mean age was 21.7±17.1mo, (range, 4–96mo) in all studied patients. There was no statistically significant difference (P=0.561) between the ages of the patients in the study groups. Among all studied patients, 25 (55.6%) were males. A statistically significant difference (P=0.031) was observed in male predominance.

The clinical presentations are summarized in Figure 2.

Operative Time The operative time had a mean of 14.9±4.7min with range of 8–27min in all studied patients. There was a high statistically significant difference (P<0.001) between the studied groups with an increase in the operative time in group 2 (mean 20.1±3.3min with a range of 15–27min) compared to that in group 3 (mean 13±3.3min with range of 9–20min) and that in group 1 (mean 11.5±2.1min with a range of 8–14min).

Optic Nerve Stump Length

Intraoperative measurements The optic nerve length stump had a mean of 10.2±4.2 mm with a range of 4–20 mm in all studied patients. There was a high statistically significant difference (P<0.001) among the three groups with a decreased optic nerve length stump in group 2 (mean 6.7±1.8 mm with range of 4–10 mm) when compared to that of group 3 (mean 13.5±4.5 mm with range of 5–20 mm) and that of group 1 (mean 10.4±2.7 mm with range of 6–16 mm).

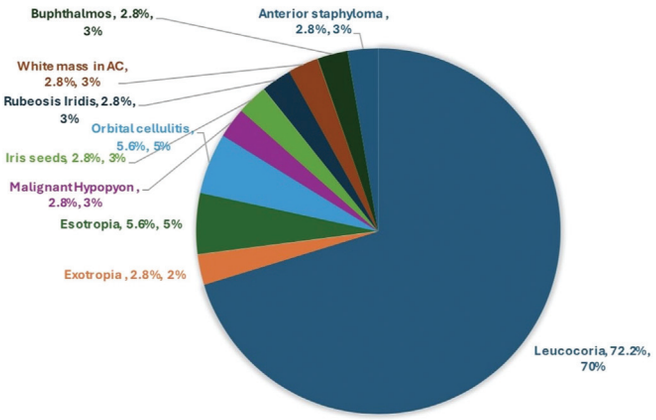


Figure 2 Pie chart showing the percentages of different clinical presentation of the patients included in the study AC: Anterior chamber.

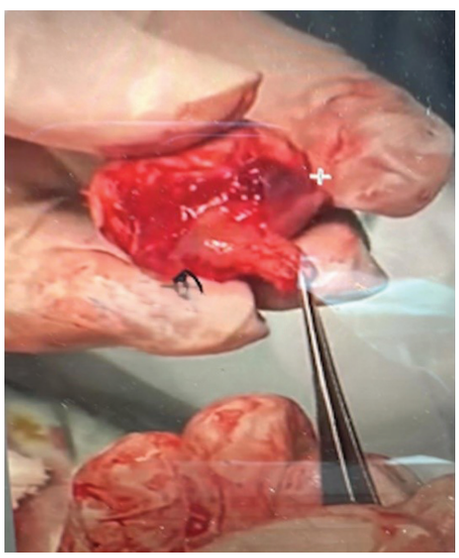


Figure 3 An enucleated globe with a long stump showing proximal severe optic nerve thickening.

However, pathology revealed that all patients had a free optic nerve stump, except for one that was in group 2, which had the least optic nerve stump.

Optic nerve thickening was observed intraoperatively in two retinoblastoma patients who were assigned to group 3. Despite diffuse thickening, a free stump could be achieved with a stump length 16 mm and 8 mm, respectively (Figure 3).

Additionally, a case of buphthalmic eye was primarily randomized in group 2; however, the surgeon failed to obtain muscle sutures with difficulty in handling the extremely thinned-out sclera; thus, a decision to utilize the haemostat clamp was taken and a free stump was successfully obtained. However, it was excluded from the analysis due to lack of randomization (Figure 4).

Pathological measurements Pathological examination of all 44 patients confirmed the presence of retinoblastoma. The mean pathological size of the optic nerve stump had a mean 9.1±4 mm, with a range of 4–18 mm in all studied patients.

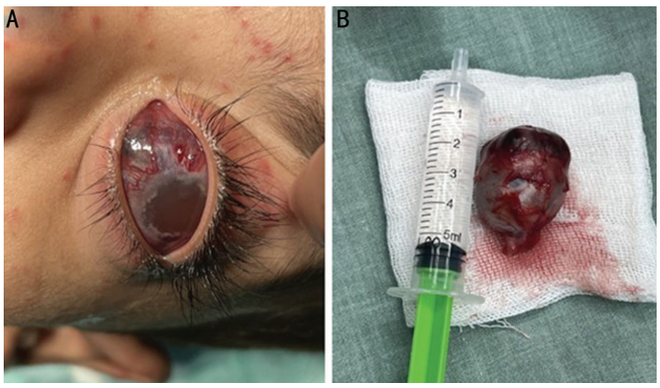


Figure 4 Retinoblastoma patient with buphthalmos (A) and enucleated buphthalmic eye (B).

A highly statistically significant difference (P<0.001) was observed in the pathological size of the optic nerve stump as evident by the decreased in stump length in group 2 (mean 5.9±1.7 mm with range of 4–10 mm) when compared with that of group 3 (mean 12±4.2 mm with range of 4–18 mm) and that of group 1 (mean 9.5±3.1 mm with range of 4–15 mm).

Pathological Optic Nerve Length Invasion Compared to the pathological findings, MRI showed a high statistical significance (P<0.001) with a moderate agreement (κ=0.591) in the diagnosis of optic nerve invasion in all studied patients. MRI signs of optic nerve invasion were true positive in 5 patients (11.36%), false positive in 5 patients (11.36%), no false negative, and true negative in 34 patients (77.27%). MRI has a sensitivity of 100%, specificity of 83.9%, positive predictive value (PPV) of 50%, negative predictive value (NPV) of 100%, and accuracy of 86.1% in the diagnosis of optic nerve invasion in all studied patients when compared with histopathology.

Pathological Extraocular Extension Regarding the pathological extraocular extension in comparison to MRI, MRI had a high statistical significance (P<0.001) with a very good agreement (κ=0.873) in the diagnosis of extraocular extension in all studied patients. MRI had a sensitivity of 100%, specificity of 96.9%, PPV of 80%, NPV of 100%, and accuracy of 97.2% in the diagnosis of extraocular extension in all studied patients when compared with histopathology.

Complications None of the reported complications of enucleation occurred in any of the three groups.

DISCUSSION

Optic nerve invasion is one of the most significant risk factors for mortality in retinoblastoma, due to the increased risk of orbital recurrence and/or metastatic disease. One of the most crucial principles of enucleation in retinoblastoma is obtaining a long optic nerve segment to ensure a pathologically free stump[8-10].

A positive optic nerve stump is considered a high-risk histopathological feature because it suggests residual microscopic disease and an increased likelihood of extraocular spread. Optic nerve invasion extending to the transection margin is associated with a significantly higher risk of metastatic disease and disease-specific mortality[9-10]. Consequently, identification of a positive optic nerve margin directly influences postoperative management, as these patients are typically treated with adjuvant systemic chemotherapy, with additional radiotherapy considered in selected cases[11-13]. Therefore, obtaining an adequate length of optic nerve during enucleation is clinically important not only to maximize the likelihood of achieving a tumour-free surgical margin but also to permit accurate pathological assessment, which forms the basis for prognostic stratification and postoperative treatment decisions[14-16].

Despite the numerous publications on the surgical management of retinoblastoma[11,17-20], reports that discuss the best surgical technique for optic nerve transection during enucleation were scarce, nevertheless recommendations for techniques of handling those highly vulnerable retinoblastoma globes.

The aim of this study was to compare three surgical techniques; Wells spoon, muscle traction sutures, and a haemostat clamp, to achieve a long free optic nerve stump while safely handling the globe during optic nerve transection in the enucleation of advanced retinoblastoma.

Few studies have discussed the instruments and approach used in optic nerve transection to obtain long stump. Shields *et al*[21] in 1992, based on their clinical experience, recommended using long, minimally curved scissors to cut the optic nerve near the orbital apex to achieve longer segments. They also advocated a nasal approach like our practice, as the optic nerve is nasally positioned in the posterior orbit, making this approach subjectively easier. They also applied traction on the stump of the severed medial rectus muscle using a clamp. Long, minimally curved scissors were used to cut the optic nerve near the orbital apex. Clamps and snares were not advised, and orbital tissue cautery was avoided.

Coats *et al*[22] confirmed Shields *et al*'s[21] recommendations regarding the use of minimally curved scissors but found that a temporal approach yielded longer mean optic nerve segments than a nasal approach. However, more attempts to cut the nerve were required in the temporal approach than the nasal approach.

A critical finding of Coats *et al*'s[22] study was that strongly curved scissors consistently resulted in shorter optic nerve segments regardless of the approach or technique used, even when these scissors were tilted aggressively towards the orbital apex.

Accordingly, minimally curved or straight scissors combined with a nasal approach appear to offer the best balance between ease of use and achieving a long optic nerve segment.

Schiedler *et al*[23] suggested that the enucleation snare demonstrates significant advantages over traditional scissors in paediatric retinoblastoma cases, particularly in achieving longer optic nerve segments, ensuring nearly bloodless transection, and providing a perpendicular surgical margin for accurate histopathologic evaluation. Despite the learning curve associated with its use, the ability of the snare to access the deeper orbital apex and minimize bleeding makes it a valuable tool for enucleation in children with advanced retinoblastoma.

In this study, the recommendations of previous studies for the use of straight scissors applied *via* the nasal approach was followed. However, we were also concerned with the technique of handling those vulnerable globes to minimize the risk of extra scleral spread.

The most frequently used technique adopted by most oculoplastic surgeons in practice is muscle stump traction yet not being evidence-based studied[14-15]. Furthermore, facing difficult situations during enucleation, such as radiologically proven extra scleral extension, buphthalmic eyes, in which muscle sutures may increase the risk of perforation, required the evolution of other surgical solutions that minimize hazardous manipulations of the globe.

Wells spoon is a commercially available tool that is not very widely used. It has a notch to safely accommodate and elevate the globe during optic nerve transection. Because the spoon provides uniform support behind the globe, it helps maintain the minimal manipulation required in retinoblastoma surgery to prevent accidental globe perforation. Its introduction behind the globe necessitates a clinical and radiological exclusion of any posterior scleral thinning. In our practice, it offered a safe rapid globe elevation to ensure a long optic nerve stump. However, being not widely available inspired searching for other more available tools that safely grip the optic nerve while securing a long stump. The haemostat clamp was used in this study as a traction tool as well as a blunt guide for the straight scissors gliding on its nasal side towards the orbital apex. It has the advantage of sparing any globe rough manipulations or tractions, making it a safe procedure during enucleation for high-risk cases such as buphthalmic eyes. It required a slightly longer duration than the well spoon yet both required a significantly shorter duration than muscle traction. This technique achieved the longest mean stump length (13.5±4.5 mm).

Furthermore, introducing this blunt haemostat allowed palpation of the optic nerve prior to transection, regarding its thickness and whether it could be clamped or not (which indicates optic nerve extension of the tumour).

The operative time required for enucleation in this age group is important to limit the hazards of general anaesthesia. The operative time was shortest with the Wells spoon technique (11.5±2.1min), followed by the artery clamp (13±3.3min) and muscle traction sutures (20.1±3.3min; $P<0.001$). The observed difference in the operative time could be attributed to the complexity of the procedure. Furthermore, the complexity of the procedure hinders the reproducibility of good results, making learning curves slower and more difficult to follow by trainees.

Optic nerve stump length was measured twice, intraoperatively and then during pathological assessment. Pathological measurements confirmed that the longest stump was achieved in group 3 (12±4.2 mm).

The pathological assessment of the length of the optic nerve specimen appeared to be shorter than that of the intraoperative measurement, which may be due to exposure to air or the use of formalin during tissue processing. This stump shrinkage was consistent with the findings of Abramson *et al*[24] where the pathologist measured a mean shrinkage of 30.3%. We believe that the intraoperative stump measurement gives a more accurate assessment and should be a common practice.

MRI is a highly accurate and valuable imaging modality for the assessment of optic nerve invasion and extraocular extension in retinoblastoma, which supports its integration into clinical practice. This may have a significant implication on the surgical technique of enucleation advising caution during muscle hooking, transection, and optic nerve cutting[25-30].

Despite obtaining a significant positive result favouring the haemostat clamp technique, a larger sample size could have strengthened the outcomes and highlighted the possible complication of each technique. Furthermore, as all procedures were performed by a single surgeon, the haemostat clamp technique should be performed by other surgeons to test for the potential learning curve and reproducibility of this technique in other centres. Future studies should include multicentre validation with larger cohorts and assessment of long-term outcomes, including orbital recurrence, implant-related complications, and survival, to establish the broader clinical utility of this technique.

In conclusion, based on our study, the haemostat clamp technique can be prioritized for advanced retinoblastoma cases in which achieving the longest possible optic nerve stump is critical. The Wells spoon technique offers a balanced approach in less complex cases with reduced operative times and fewer complications. The muscle traction suture technique may be reserved for cases where other methods are not feasible.

Lastly, having more than one facility and technique is always a source of safety for the surgeon if one is inadequate, and another is available, especially in this life-threatening procedure.

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Authors' Contributions: Hamza H, Alahmadawy Y, Abdullatif A were involved in the conception and design, Fawzy L, Abdullatif A, Alahmadawy Y contributed in the analysis and interpretation of the data; the drafting of the paper; Alahmadawy Y, Abdullatif A share in revising it critically for intellectual content; and the final approval of the version to be published was done by Abdullatif A, Alahmadawy Y, Hamza H; and that all authors agree to be accountable for all aspects of the work.

Data Availability Statement: All data generated or analysed during this study are included in this published article.

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