Original Article

Laser Circumcision Using Holmium YAG in Paediatric Patients: A Novel Technique with Promising Outcomes

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Abstract

Background: Circumcision is a frequently performed paediatric surgical procedure, undertaken for both cultural and medical indications. While the conventional techniques may be associated with postoperative pain, bleeding and delayed healing, laser technology may reduce these morbidities, but paediatric data relating specifically to the Holmium:YAG laser remain limited. **Objective:** This study aimed to describe the early clinical outcomes of circumcision performed with the Holmium:YAG laser in children. **Methods:** A prospective, single-centre descriptive case series of 60 consecutive boys aged 2 to 11 years who underwent Holmium:YAG laser circumcision under general anaesthesia at a tertiary care surgical department between March 2023 and February 2025. Operative time, estimated intraoperative blood loss, postoperative pain, bleeding, infection, and scarring or fibrosis were recorded intraoperatively and at 6 hours, 24 hours, 1 week and 3 weeks. Data were summarised descriptively; no comparative or inferential analysis was undertaken. **Results:** All 60 procedures were completed with the laser without conversion, and follow-up was complete at every time point. Mean operative time was 15.02 ± 2.93 minutes (range 10.2–19.7). Estimated blood loss was less than 5 ml in 55 patients (91.7%) and 5–10 ml in 5 (8.3%); no patient required transfusion or an additional haemostatic procedure. The mean pain score at 6 hours was 2.65 ± 1.33 (range 1–5), and every child recorded a score of zero at 24 hours, 1 week and 3 weeks. Mild or moderate oozing was documented at 6 hours in 42 patients (70.0%), all of which settled spontaneously; no bleeding was recorded at 24 hours, 1 week or 3 weeks, and no infection occurred at any assessment. At 3 weeks, appearances at the incision line were graded as none or minimal in 17 patients (28.3%), moderate, defined as scarring producing a mild glanular tilt, in 27 (45.0%), and as fibrosis producing chordee in 16 (26.7%); no patient required intervention during the follow-up period. **Conclusion:** Holmium:YAG laser circumcision was feasible in this paediatric cohort and was associated with short operative times, low estimated blood loss, rapid resolution of pain and no infective complications over three weeks. Early oozing was common though self-limiting. Scarring exceeding the minimal grade was recorded in 43 of 60 children (71.7%) at three weeks, including appearances graded as glanular tilt or chordee, although none required intervention and three weeks is too early an interval to characterise the final cosmetic result. As a single-arm series without a comparator, this study cannot establish superiority over conventional or device-assisted techniques; comparative studies with longer follow-up are required.

Keywords: Circumcision, Lasers, Solid-State, Paediatrics, Postoperative Complications; Treatment Outcome

Introduction

Circumcision as a surgical procedure has been undertaken for religious, cultural and medical reasons for a long time.[1,2] In children, it is indicated for phimosis, recurrent balanoposthitis and hygiene difficulties associated with a non-retractile foreskin.[3] Despite being a commonly undertaken procedure, it is not without risk. Conventional scalpel-based circumcision, which typically involves sutures and electrocautery, may be complicated by bleeding, postoperative pain, infection, delayed healing and unsatisfactory cosmetic results.[4] In children, where the procedure is often elective and the tissue small, the balance between therapeutic benefit and procedural risk requires particular care.[2]

Numerous modifications have been introduced in response, including device-assisted techniques[5] such as the Gomco clamp[6] and the Plastibell ring.[7] These have simplified the operation and shortened operative time, but complications persist. The search for greater precision and more reliable haemostasis has led to the progressive introduction of laser technology into soft tissue surgery,[8] and the Holmium:YAG laser is now well established in urological practice, although its application to circumcision in children remains sparsely reported.[9] The Holmium:YAG laser emits in pulsed mode at a wavelength of 2140 nm.

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This emission is strongly absorbed by water, giving a shallow penetration depth of approximately 0.4 mm together with efficient coagulation and controlled vaporisation, and therefore permitting precise incision with limited collateral injury.[10] Compared with monopolar electrocautery, it produces less lateral thermal spread, and its simultaneous cutting and coagulating action may reduce both intraoperative bleeding and the need for suture closure.[11]

The available clinical evidence is dominated by other laser types. In a systematic review and meta-analysis of seven studies, Scarcella *et al*., found lower postoperative pain scores, fewer complications and better cosmetic outcomes with laser-assisted circumcision than with conventional techniques, an advantage driven principally by studies using CO2 lasers.[12] Data on the Holmium:YAG laser were limited and drawn largely from mixed or adult cohorts, and the subgroup analysis did not demonstrate a cosmetic advantage for this laser type. The authors identified the absence of paediatric-specific data using this modality as a gap in the literature.[12]

Laser circumcision also carries practical constraints that bear on any assessment of its role. Holmium:YAG systems require considerable capital outlay, ongoing maintenance, consumable delivery fibres and dedicated laser safety provisions, and their availability is consequently uneven, particularly in lower-resource settings where the majority of paediatric circumcisions are performed. Outcomes may further depend on operator familiarity, and variability in operator experience has been proposed as one explanation for the heterogeneity observed between published laser series.[12]

Against this background, we conducted a prospective descriptive case series to document the early clinical outcomes of Holmium:YAG laser circumcision in a paediatric cohort. The outcomes of interest were operative time, estimated intraoperative blood loss, postoperative pain, bleeding, infection, and scarring or fibrosis over three weeks of follow-up. The study was designed to characterise the technique in children rather than to compare it with any alternative.

Materials and Methods

Study design and setting

This was a prospective, single-centre descriptive study conducted in the Department of Paediatric Surgery of a tertiary care teaching hospital between March 2023 and February 2025. A descriptive design is reported because no comparator group was recruited and the study was not designed to test a hypothesis. All eligible children presenting for circumcision during the study period were enrolled consecutively, and no formal sample size calculation was performed. The report follows the STROBE recommendations for observational studies.

Ethical Consideration

The study protocol was approved by the Institutional Ethics Committee for Human Research of Lokmanya Tilak Municipal Medical College and Lokmanya Tilak Municipal General Hospital, Sion, Mumbai (reference LMH/IEC/2023/125). Written informed consent was obtained from a parent or legal guardian of every participant before enrolment, and assent was additionally obtained

from children old enough to provide it. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Participants

Sixty consecutive male children aged 2 to 11 years were included. Inclusion criteria were circumcision undertaken for religious or cultural reasons, or for a medical indication such as phimosis or recurrent balanoposthitis. Exclusion criteria were active genital infection, paraphimosis, significant adhesions between the prepuce and glans, genital trauma, and any requirement for a concurrent surgical procedure. Children under two years of age were not eligible. In this age group conventional circumcision is generally preferred to energy-based techniques because of the delicate infant anatomy, the frequency of preputial adhesions and the potential for thermal injury to adjacent tissue, although no universal guideline contraindicates laser circumcision below this age.

Anaesthesia and Perioperative Care

All procedures were performed under general anaesthesia. Anaesthesia was induced with intravenous propofol and maintained with inhalational sevoflurane, with spontaneous ventilation through a laryngeal mask airway. From eight hours after surgery, and for home care thereafter, ibuprofen oral suspension was prescribed at 5-10 mg/kg thrice daily for three days and subsequently as required. All children were managed as day cases.

Operative Technique

Each procedure was performed by an operating surgeon with prior experience in laser surgery, using a standardised technique. A total of 3 surgeons contributed across the series. The three artery-forceps technique of circumcision was employed throughout. Laser energy was delivered from a Holmium:YAG generator through a 200 µm core silica fibre held in near contact with the prepuce, using a pulse energy of 4.0 J, a pulse duration of 250–350 µs and a pulse frequency of 5–8 Hz, corresponding to an average power of 20–32 W. No cooling system was required during laser activation. Electrocautery was not used at any stage and no sutures were placed; the wound edges were left apposed without further intervention. A standard dressing was applied and the child discharged once comfortable.

Outcome Measures and Definitions

Data were recorded intraoperatively and at four scheduled follow-up assessments: 6 hours, 24 hours, 1 week and 3 weeks after surgery.

Operative time was measured, and blood loss was estimated by gauze weighing and graded on a single volumetric scale applied both intraoperatively and at each follow-up assessment: none; mild, less than 5 ml; moderate, 5 to 10 ml; and severe, more than 10 ml.

Postoperative pain was assessed at each follow-up on a 0 to 10 visual analogue scale. The same instrument was applied to

every child irrespective of age. Parents assigned the score for children too young to self-report. The limitations of this approach in the younger children are addressed in the discussion.

Wound infection was graded at each assessment. Children who required no additional treatment were classified as non-infected. Infection was graded as mild in the presence of erythema or colour change alone, moderate in the presence of exudate or necrosis of less than 1 cm², and severe in the presence of continuous discharge or necrosis exceeding 1 cm². A healing wound was defined as intact skin across the apposed wound edges without exudate or swelling. These categories were defined by the study investigators to facilitate the classification of outcomes within the study population.

Appearances at the incision line were graded at three weeks as none or minimal; moderate, denoting scarring producing a mild glanular tilt; or fibrosis, denoting scarring producing chordee. All assessments were clinical, were performed by the operating investigator and were not blinded.

Statistical Analysis

The analysis was descriptive throughout. Continuous variables are presented as mean ± standard deviation with the observed range, and categorical variables as counts with percentages calculated against a denominator of 60. Data were compiled and analysed using R version 4.5.1. No inferential or comparative statistical testing was undertaken, since the study comprised a single arm with no control group and no a priori hypothesis. No data were missing: all 60 children completed all four scheduled assessments, so no imputation was required.

Result

Sixty male children underwent Holmium:YAG laser circumcision during the study period. Mean age was 6.88 ± 2.43 years (range 2–11) and mean weight 23.69 ± 8.53 kg (range 10.4–39.8). Thirty-four children (56.7%) were younger than eight years, and five (8.3%) were aged two or three years. All 60 procedures were completed with the laser without conversion to a conventional technique, and all 60 children attended every scheduled assessment, giving complete follow-up with no missing data (Table 1).

Table 1: Baseline characteristics and operative parameters (N = 60)

Parameter	Mean ± SD or n (%)	Range
Age (years)	6.88 ± 2.43	2 – 11
Weight (kg)	23.69 ± 8.53	10.4 – 39.8
Operative time (minutes)	15.02 ± 2.93	10.2 – 19.7
Blood loss, mild (< 5 ml)	55 (91.7%)	—
Blood loss, moderate (5 – 10 ml)	5 (8.3%)	—
Blood loss, severe (> 10 ml)	0 (0%)	—

SD: standard deviation. Percentages are calculated against a denominator of 60.

Mean operative time was 15.02 ± 2.93 minutes, with the shortest procedure lasting 10.2 minutes and the longest 19.7 minutes. Estimated intraoperative blood loss was less than 5 ml in 55 children (91.7%) and between 5 and 10 ml in 5 (8.3%). No child lost more than 10 ml, and none required transfusion or an additional haemostatic procedure.

At six hours the mean pain score was 2.65 ± 1.33 (range 1–5), and no child was pain-free. At 24 hours every child recorded a score of zero, and this was maintained without exception at one week and at three weeks (Table 2). Bleeding at the wound edge was documented at six hours in 42(70.0%) children: 21 (35.0%) were graded mild and 21 (35.0%) moderate, while 18 children (30.0%) had none. Every episode settled spontaneously and none required re-exploration, suture

Table 2: Postoperative pain scores across follow-up intervals (N = 60)

Follow-up interval	Mean pain score ± SD	Range	Patients with score = 0, n (%)
6 hours	2.65 ± 1.33	1 – 5	0 (0%)
24 hours	0.00 ± 0.00	0 – 0	60 (100%)
1 week	0.00 ± 0.00	0 – 0	60 (100%)
3 weeks	0.00 ± 0.00	0 – 0	60 (100%)

VAS: visual analogue scale. Pain was scored 0–10 on a single visual analogue scale applied to all children irrespective of age; parents scored for children too young to self-report

Table 3: Postoperative complications (N = 60)

Outcome	Patients, n	Percentage (%)
Bleeding at 6 hours — none	18	30.0
Bleeding at 6 hours — mild (< 5 ml)	21	35.0
Bleeding at 6 hours — moderate (5 – 10 ml)	21	35.0
Bleeding at 6 hours — severe (> 10 ml)	0	0
Bleeding at 24 hours	0	0
Bleeding at 1 week	0	0
Bleeding at 3 weeks	0	0
Infection at 24 hours, 1 week or 3 weeks	0	0
Incision line at 3 weeks — none or minimal	17	28.3
Incision line at 3 weeks — moderate (mild glanular tilt)	27	45.0
Incision line at 3 weeks — fibrosis (chordee)	16	26.7

Grading definitions for bleeding and for appearances at the incision line are given in the Methods. All 60 children were assigned a grade at three weeks; the lowest grade combines no scarring with minimal scarring. No child required intervention for bleeding or for scarring during the follow-up period.

ligation or any other haemostatic intervention. No bleeding was recorded at 24 hours, at one week or at three weeks. No wound infection was identified at any assessment (Table 3).

Appearances at the incision line were graded in all 60 children at three weeks. Seventeen children (28.3%) were graded as having no or minimal scarring, 27 (45.0%) as moderate, denoting scarring producing a mild glanular tilt, and 16 (26.7%) as fibrosis producing chordee. No child underwent secondary medical or surgical intervention for these appearances during the follow-up period, and none was assessed beyond three weeks (Table 3).

Discussion

This prospective series describes the early outcomes of Holmium:YAG laser circumcision in 60 children. The procedure was completed with the laser in every patient without conversion, operative times were short and consistent, estimated intraoperative blood loss was low, pain scores fell to zero in every child by 24 hours and remained there, and no infection occurred at any assessment. Two findings temper this picture and are examined below: mild or moderate oozing was documented in 70.0% of children at six hours, and at three weeks most children showed more than minimal scarring at the incision line. Because the series was single-armed, these observations characterise the technique rather than establish its merit relative to any alternative.

The haemostatic behaviour observed here is consistent with the physical properties of the laser. Holmium:YAG emission is strongly absorbed by water, producing a shallow zone of tissue interaction and allowing tissue to be divided and coagulated in a single action.[10,11] In vitro comparison of Holmium:YAG with thulium fibre lasers has demonstrated limited lateral thermal spread at clinically relevant pulse settings.[13] In this cohort that translated into estimated blood loss below 5 ml in 91.7% of children, no requirement for transfusion or additional haemostatic manoeuvres, and an operative field that required neither electrocautery nor suture ligation.

Mean operative time was 15.02 minutes, with a narrow range. These data permit no comparison with conventional circumcision, since no conventional arm was recruited and no institutional benchmark was recorded. For context, Scarcella *et al*. found that laser techniques as a group did not shorten operative time relative to conventional surgery, although a subgroup benefit was evident for CO2 lasers,[12] and Ronchi *et al*. reported reduced operative time with CO2 laser circumcision, attributing it to improved haemostasis and a reduced need for suturing.[16] Our times are of a similar order to those reports, which suggests that the Holmium:YAG laser does not impose a time penalty in children, but this remains an observation rather than a comparison.

The most directly comparable published experience is that of Huang *et al*., who used a Holmium:YAG laser with broadly similar technical parameters in 81 patients (41 laser, 40 conventional) drawn from a mixed adolescent and adult population, and reported less haematoma formation and improved healing in the laser group.[14] Kuo *et al*. described comparable findings in adults.[9] Neither series reports paediatric outcomes in detail. The present cohort adds data restricted to children aged 2 to 11 years, treated with a single laser platform and a uniform operative technique, with structured outcome recording at four fixed intervals and no loss to follow-up.

Postoperative pain followed a consistent trajectory: a mean of 2.65 at six hours with no child pain-free, followed by a score of zero in every child at 24 hours that persisted at one and three weeks. The rapidity of this decline is directionally consistent with the randomised comparison reported by Xu *et al*., who found significantly lower pain scores at 24 hours and seven days after CO_2 laser circumcision in 300 adult males.[15] Two caveats apply, and both are material. First, the timing of the analgesic regimen coincides with the observed decline. Scheduled ibuprofen was commenced eight hours after surgery, so the scores recorded at six hours precede any oral analgesia while every subsequent score was obtained under a scheduled regimen. In the absence of a comparator, the contribution of the analgesia cannot be separated from that of the operative technique, and the trajectory should not be attributed to the laser. Second, pain assessment in this age group is intrinsically limited. The same 0 to 10 visual analogue scale was applied to every child irrespective of age, yet 34 children (56.7%) were younger than eight years and five were aged two or three, below the age at which self-report visual analogue scales have been validated. In the youngest children the score is therefore an observer's estimate expressed on a self-report instrument. The uniformity of the recorded zeros may reflect the resolution of that instrument as much as the complete absence of pain. These findings are best read as consistent with a comfortable early recovery rather than as a precise measurement of it.

Early oozing at the wound edge was common, occurring in 42 of 60 children (70.0%) at six hours and divided evenly between mild and moderate grades. Its clinical significance nonetheless appears limited. Every episode settled spontaneously, none required re-exploration or any other haemostatic intervention, and no bleeding at all was recorded at 24 hours, one week or three weeks. Bleeding was graded on the same volumetric scale used intraoperatively, so the mild and moderate grades correspond to estimated losses below 5 ml and of 5 to 10 ml respectively. Comparable early, self-limiting ooze has been described after CO_2 laser circumcision in children by How *et al*.[20] The clinically meaningful distinction is between early ooze from a sutureless wound edge, which resolved uniformly in this series, and reactionary or secondary haemorrhage, of which there were no cases.

No wound infection was identified at 24 hours, one week or three weeks. This is consistent with the sealed, coagulated wound margin produced by laser division and with the absence of retained suture material, though a cohort of this size followed for three weeks cannot exclude uncommon infective complications. Vaos reported minor complications including oedema and delayed healing after Nd:YAG contact circumcision in children;[19] oedema, haematoma and wound dehiscence were not recorded as discrete variables in the

Present protocol, and no comparison can therefore be offered on those outcomes.

Appearances at the incision line at three weeks were the least favourable finding in this series, and they require careful statement. Every child was assigned a grade: none or minimal in 17 (28.3%), moderate in 27 (45.0%) and fibrosis in 16 (26.7%), so that 43 children (71.7%) were graded above the lowest category. Under the grading scheme used, the moderate grade denotes scarring producing a mild glanular tilt and the fibrosis grade denotes scarring producing chordee. No child required medical or surgical intervention for these appearances during the study period.

Several considerations bear on how these figures should be read, and none of them permits the finding to be set aside. Three weeks is early in scar maturation, and early contracture at a sutureless wound edge may remodel substantially over subsequent months; appearance at this interval is therefore a poor guide to the final result. Against that, no child was assessed beyond three weeks, so remodelling is an expectation rather than an observation, and the proportion graded above minimal is high enough that it cannot be attributed to measurement noise. These data do not support any claim of cosmetic advantage for the Holmium:YAG laser. They are consistent with the subgroup analysis of Scarcella *et al*., which found a cosmetic benefit for CO_2 lasers but not for Holmium:YAG.[12] It is also relevant that the favourable paediatric cosmetic outcomes reported by Gorgulu *et al*. and Mungnirandr *et al*. were achieved with CO_2 lasers combined with cyanoacrylate tissue adhesive for wound apposition,[17,18] whereas in the present series the edges were left apposed without adhesive or suture, a technical difference that may bear directly on scar quality. Follow-up extending through scar maturation, using a validated scar score and an objective assessment of penile axis, together with parent-reported cosmetic satisfaction, is necessary before the aesthetic profile of this technique can be characterised.

Practical considerations constrain the wider applicability of the technique. Holmium:YAG platforms require substantial capital investment, regular servicing, consumable delivery fibres, laser safety infrastructure and trained personnel. These requirements limit availability precisely in the lower-resource settings where a large share of paediatric circumcisions is performed and where device-assisted methods remain the pragmatic standard.[5] A further consideration is that every procedure in this series was performed under general anaesthesia, which carries its own cost, staffing requirement and anaesthetic exposure, and which contrasts with device-assisted techniques that are frequently performed under local anaesthesia. Any economic case for laser circumcision would need to weigh shorter theatre occupancy and the avoidance of sutures and electrocautery against these fixed and recurrent costs. The present study collected no cost data and cannot make that case. The strengths of this series lie in its homogeneity and completeness. The cohort was restricted to children, a single laser platform and a single operative technique were used throughout, outcomes were recorded prospectively at fixed intervals against pre-specified categories, and follow-up was complete for all 60 patients at every assessment with no missing data.

Several limitations must be stated. The study was a single-arm series with neither a concurrent nor a retrospective comparator, so no claim about the relative merits of laser and conventional circumcision can be supported by these data, and no inferential statistics were performed. It was conducted in one tertiary centre by a small number of operators (3 operators), which limits generalisability, particularly to settings without laser infrastructure. Follow-up extended only to three weeks, sufficient for early complications but not for scar maturation, meatal stenosis or any late functional outcome. Follow-up did not extend through scar maturation, which is a particular constraint given the appearances recorded at three weeks. A single 0 to 10 visual analogue scale was applied to all children irrespective of age, which is not a validated approach below approximately eight years and limits the weight that can be placed on the pain findings; the concurrent scheduled analgesic regimen further prevents the pain trajectory from being attributed to the operative technique. Blood loss, bleeding severity and appearances at the incision line were graded clinically, without blinding and without a validated instrument, which introduces the possibility of observer bias in the direction of favourable outcomes. All procedures were performed under general anaesthesia, so these findings do not extend to settings in which circumcision is undertaken under local anaesthesia. Cosmetic outcome was not assessed by parents or by any patient-reported measure. Finally, no formal sample size calculation was undertaken; the cohort comprised the eligible children presenting during the study period.

Conclusion

Holmium:YAG laser circumcision was technically feasible in all 60 children in this series and was associated with short operative times, low estimated intraoperative blood loss, rapid resolution of postoperative pain and an absence of infection over three weeks of follow-up. Early oozing at the wound edge was common but uniformly self-limiting. Appearances at the incision line were graded above the minimal category in 43 of 60 children at three weeks, including scarring recorded as producing glanular tilt or chordee; no child required intervention, but this interval is too early to determine the final cosmetic outcome and the finding must temper any aesthetic claim for the technique. These results describe favourable short-term outcomes in a single paediatric cohort; they do not establish that the technique is superior to conventional or device-assisted circumcision. Comparative studies incorporating a control group, validated age-appropriate pain and scar assessment, longer follow-up and formal cost analysis are required before wider adoption can be recommended.

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Conflicts of interest

There are no conflicts of interest

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