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Case Series

The impact of the RoboticScope™ exoscope on cleft lip and palate surgery: surgical advances stimulated by last generation technologies

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ABSTRACT

RoboticScope™ (RS™) is a robotic exoscope that integrates three-dimensional high-definition visualization with hands-free control, offering potential advantages in microsurgical procedures. Cleft lip and palate (CLP) repair require a small and deep surgical field, precise tissue handling, and presents ergonomic challenges for surgeons and limitations in surgical teaching. This case series describes. The feasibility, safety, advantages, and limitations of using RS™ during cheiloplasty and palatoplasty. Eight patients with unilateral cleft lip and/or palate were included: four cheiloplasties and four palatoplasties, half performed with RS™ and half with conventional techniques by the same surgical team. Intraoperative variables, postoperative outcomes, and surgeon satisfaction were evaluated. No differences were observed between groups regarding bleeding, aesthetic-functional outcomes, or short-term complications at six months. Surgical time was longer when using RS™, reflecting the initial learning curve. Surgeons reported superior visualization, improved ergonomics, and enhanced educational value with RS™, allowing real-time sharing and recording of procedures. Despite limitations related to equipment cost and unfavorable angles in specific surgical steps, RS™ demonstrated technical feasibility and safety in CLP surgery. This case series represents the first clinical report of RS™ use in cleft lip and palate repair and suggests that it is a promising adjunct to conventional techniques, particularly for microsurgical precision, ergonomics, and surgical education.

Keywords: RoboticScope, Exoscope, Cleft lip and palate surgery, Cheiloplasty, Palatoplasty

INTRODUCTION

Cleft lip with or without cleft palate is the most common congenital malformation of the head and neck. It affects feeding, hearing, and speech, thus having multiple effects on the individual and society in terms of economic costs, loss of productivity, psychosocial effects, and increased morbidity and mortality at all stages of life.[1]

The treatment is multidisciplinary. In our center, cheiloplasty is generally performed between 3 and 6 months of age and palatoplasty at 6-18 months. This is why surgical repair is challenging because it requires a small and deep surgical field and delicate handling and dissection of the tissues. Furthermore, these types of procedures are physically demanding for the surgeon, as they require awkward postures. Additionally, teaching this type of surgery to students is also challenging due to limited access and visibility.

Throughout history, multiple techniques and tools have been described that help to have better access, visualization and manipulation of tissues, such as the use of magnifying glasses with frontal light, microscopes and the robotic system. Recently, microsurgery is facing a new trend: the convergence of endoscopic and microscopic

visualization principles, resulting in lighter and more versatile surgical exoscopes.

RoboticScope™ (RS™) is a robotic exoscope that combines the benefits of a traditional microscope with an innovative digital system, which includes a three-dimensional (3D) digital camera that transmits high-resolution images in real time to 2 micromonitors placed in front of the surgeon's eyes (Figure 1).

Figure 1: RoboticScope™ and its use in palatoplasty.

It translates the surgeon's head movements into robot-controlled movements and camera adjustments to change the field of view. It frees the surgeon from postures determined by the position of the optical apparatus of a conventional microscope; in addition to offering other advantages such as a larger field of view, focal length, wide magnification range and the exchange of information in the operating room, all of which have a high impact on surgical interventions of varying complexity. Its utility has been described mainly in microsurgical procedures, especially in the area of neurosurgery. To date, its use, feasibility and safety in cleft lip and palate (CLP) surgeries have not been described.

Therefore, the aim of this case series is to describe the feasibility, utility, advantages, and disadvantages of using the RS™ exoscope in cheiloplasties and palatoplasties versus conventional techniques performed at the Dr. Manuel Gea González General Hospital.

CASE SERIES

This prospective case series included eight patients with non-syndromic unilateral cleft lip and/or palate who underwent primary surgical repair at the Plastic and Reconstructive Surgery Department of Dr. Manuel Gea González General Hospital in June 2024. Inclusion criteria were unilateral cleft lip and/or palate, no previous surgical intervention, and complete clinical records. Patients with bilateral clefts, syndromic diagnoses, or secondary procedures were excluded. Institutional review board approval was obtained, and written informed consent was provided by the parents of all patients. Four unilateral cheiloplasties (Millard technique) and four palatoplasties (Von Langenbeck technique) were performed. Half of the procedures were conducted using RoboticScope™ assistance and half using conventional visualization, all by the same surgical team following prior training with the device. Data collected included patient demographics, type of surgery, operative time, intraoperative bleeding, aesthetic-functional outcomes, short-term complications (6 months), and surgeon satisfaction assessed using a Likert scale. Overall, five patients (62.5%) were male and three (37.5%) females, with a mean age of 9.4 months (range 6–14 months). No intraoperative or postoperative complications were observed. Bleeding volume and aesthetic-functional outcomes were comparable between RS™-assisted and conventional procedures, with all cases rated as very good (+++) (Table 1). Surgical time was longer in RS™ cases, with an average increase of 19.5%. Surgeon satisfaction was high, particularly regarding visualization quality, ergonomic comfort, and educational value (Figure 2).

Table 1: Demographic characteristics, surgical procedures, and perioperative outcomes of patients undergoing cleft lip and palate repair with RoboticScope™ – assisted and conventional techniques. Data are presented as number (percentage) or mean values. No differences were observed between groups in bleeding volume, aesthetic-functional outcomes, or short-term postoperative complications at 6-month follow-up.

Variables	RS™ group, n=4 (%)	Conventional group, n=4 (%)	Total, n=8 (%)
Male sex	2 (50)	3 (75)	5 (62.5)
Female sex	2 (50)	1 (25)	3 (37.5)
Cheiloplasty	2 (50)	2 (50)	4 (50)
Palatoplasty	2 (50)	2 (50)	4 (50)
Mean age (months)	8.8	10.0	9.4
Mean surgical time (min)	111.3	74.3	—
Mean bleeding (cc)	18.8	20.0	—
Aesthetic-functional result (+++)	4 (100)	4 (100)	8 (100)
Complications	0 (0)	0 (0)	0 (0)

Surgical time was longer with the RS™, associated with a longer operative time during critical surgical steps in the critical steps assigned to each of the members of the surgical team, demonstrating that prior training in

microsurgery has an important role. The results of the Likert survey showed high satisfaction of surgeons when using this tool, emphasizing the better quality of intraoperative vision, effectiveness of the surgical maneuver and excellent ergonomics during the procedure by having a better posture of the cervical spine (Figure 3), and they added that they would use it again in their practice if it were available.

Figure 2: (A and B) Preoperative and postoperative baseline and frontal view of a patient with complete right CLP who underwent Q M2 with RS™, (C and D) preoperative and postoperative baseline view of a patient with bilateral cleft palate who underwent P VL with RS™. Both results were very good (+++) as rated by the surgeon and family.

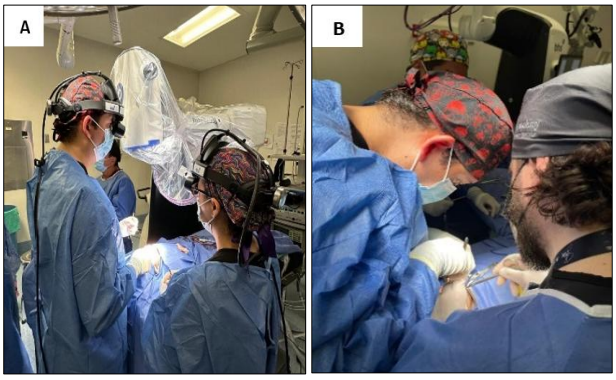

Figure 3: (A) 4th year PRS resident performing P VL with RS™, adequate cervical position is observed, and (B) same resident performing conventional palatoplasty, greater neck flexion is observed during the surgical procedure.

It is important to mention that with the use of the RS™, the procedures could be shared with the entire team, including observers, and were easily recorded to enhance the education of surgeons in training (Figure 4).

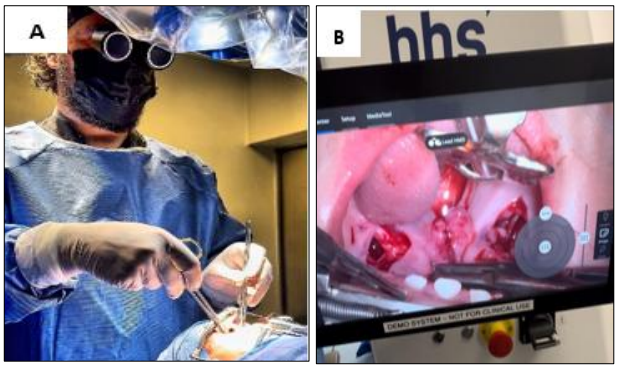

Figure 4 (A and B): Von Langenbeck palatoplasty recorded and shared live with the team.

DISCUSSION

Cleft lip and palate repair requires optimal visualization, microsurgical precision, and ergonomic conditions due to the reduced surgical field and delicate tissue manipulation. Improvements in optical technology have historically contributed to refinements in cleft surgery, including the use of loupes and operating microscopes.[1,4,9] This case series represents the first clinical report describing the use of RS™ in cheiloplasty and palatoplasty.

In the present series, no differences were observed in bleeding, aesthetic-functional outcomes, or short-term complications between RS™-assisted and conventional surgeries. These findings are consistent with previous reports evaluating microscope-assisted cleft surgery, which demonstrated improved visualization without increasing complication rates.[4,9] Similarly, robotic and exoscopic systems in microsurgery have shown comparable safety profiles to conventional visualization methods.[3,5,6]

A longer surgical time was observed in RS™ cases, with an average increase of 19.5%. This finding aligns with previously described learning curves in both palatoplasty and robotic or exoscopic systems.[3,7,8] Importantly, the increase in operative time was more pronounced among junior residents, supporting the notion that prior microsurgical experience influences adaptation to advanced visualization technologies.

One of the most notable advantages of RS™ was improved ergonomics, reflected in better cervical spine posture and reduced physical strain. Ergonomic benefits have been widely reported with exoscopic and robotic visualization systems in neurosurgery and microsurgery, contributing to surgeon comfort and potentially reducing long-term work-related musculoskeletal disorders.[5,6]

Additionally, RS™ provided substantial educational value by allowing real-time sharing and recording of procedures. This advantage has been previously highlighted in robotic and simulator-based cleft surgery studies, emphasizing their role in surgical training and skill acquisition.[7]

Limitations of this case series include the small sample size, single-center experience, and short follow-up period. Nevertheless, the findings provide preliminary clinical evidence supporting the feasibility and safety of RS™ in CLP surgery.

CONCLUSION

This case series demonstrates that RS™ is a technically feasible and safe adjunct in cleft lip and palate surgery, providing comparable aesthetic-functional outcomes and complication rates to conventional techniques. Its main advantages include enhanced three-dimensional visualization, improved microsurgical precision, superior ergonomics, and significant educational benefits through real-time sharing and recording of procedures. Although surgical time was longer due to the learning curve and equipment cost remains a limitation, this study advances current knowledge by providing the first clinical evidence of RS™ application in CLP repair. Further studies with larger cohorts and long-term follow-up are warranted to define its role in routine cleft surgery practice.

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