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Review

ROLE OF STENTING IN ENDONASAL DACRYOCYSTORHINOSTOMY: MULTIPLE CHALLENGES OF THE CURRENT APPROACH

Ekaterina Kondratishko[1,#], Dace Tjurina[1,4,5], Mihails Bekers-Ancipolovskis[2,4], and Aleksejs Derovs[1,4,5,6]

[1] JSC Veselības Centru Apvienība, 16 Andreja Saharova Str., Rīga, LV-1021, LATVIA

[2] Pauls Stradiņš Clinical University Hospital, 13 Pilsoņu Str., Rīga, LV-1002, LATVIA

[3] University of Latvia, 19 Raiņa Blvd., Rīga, LV-1586, LATVIA

[4] Department of Internal Diseases, Rīga Stradiņš University, Dzirciema Str. 16, Rīga, LV-1007, LATVIA

[5] Rīga East University Hospital, 2 Hipokrāta Str., Rīga, LV-1038, LATVIA

[6] Department of Infectology, Rīga Stradiņš University, Dzirciema Str. 16, Rīga, LV-1007, LATVIA

[#] Corresponding author, ek@conmed.lv

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The standard procedure for dacryocystorhinostomy (DCR) employs routine stenting during the operation. According to different sources, the overall stent indwelling time ranges from six weeks to six months or even longer. Placement of a stent promotes rhinostoma formation and prevents stenosis. Since the introduction of this technique, many studies have been conducted to assess the results of DCR with and without the use of stents, the stent material, as well as the time period after which the stents were removed. This review discusses the relevant literature on stenting in endonasal dacryocystorhinostomy, which was available in PubMed over the last ten years. Equally good endonasal dacryocystorhinostomy (enDCR) results have been obtained for patients with and without a stent. However, the use of stents is sometimes associated with multiple additional complications: formation of granulations at an earlier postoperative period, infection of the lacrimal drainage system, and canalicular laceration. The use of Mitomycin C, topical steroids, antibiotics, and silver nitrate has a different impact on reducing the occurrence of these complications. Further studies are needed to develop more accurate indications for the use of stents during enDCR, as well as the timing of their removal, and the use of adjunctive topical medication.

Keywords: *timing of stent removal, DCR postoperative management, nasolacrimal duct obstruction, granulation, silver nitrate, stenting guidelines.*

INTRODUCTION

Since 1904, the gold standard surgical treatment for nasolacrimal duct obstruction (NLDO) has been external dacryocystorhinostomy (extDCR), described by Adeo Toti. Although Caldwell first described endonasal dacryocystorhinostomy (enDCR) in 1893 (Caldwell, 1893), due to insufficient technical capabilities, enDCR has not been used as widely as it is possible today. Moreover, enDCR has wider indications and a number of advantages over extDCR. Currently, multiple studies have reported success rates for enDCR that are comparable to extDCR (Cokkeser *et al.*, 2000; Tsirbas *et al.*, 2004; Ben Simon *et al.*, 2005; Huang *et al.*, 2014). Stenting for DCR has gained popularity since in 1967 when Gibbs described a technique of inserting a silicone rubber tube (Gibbs, 1967). Today, stenting is recommended as a standard technique for DCR procedure (Nerad, 2010, p. 290; Ullrich *et al.*, 2022).

Stenting is performed at the end of the procedure, and the stent is left for a period of six weeks to six months, sometimes up to 12 months. Possible complications are granulation tissue formation in the region of the rhinostomy at earlier stages, infection of the lacrimal drainage system, and punctual-canalicular laceration (cheese-wiring effect).

The variety of stents on offer for this procedure is limited, and in our practice we observed that even stents produced by the same vendor differ in elasticity and stretchability. During the last eight years of practice in enDCR, we have used silicone stents from different manufacturers with the Chartered Engineers Certificate (CE), which were available in Latvia. Following our observations we found that cheaper silicone stents were less stretchable and more rigid, and therefore granulation tissue formation around the ostium of rhinostoma occurred more frequently. Obviously, this effect depends on silicone quality.

Several studies were reviewed from the relevant literature available on PubMed for the last ten years. The studies on endonasal dacryocystorhinostomy mostly involved randomised controlled trials (RCT) and retrospective studies (RS), where the outcomes of DCR with and without stent were compared, as well as the duration of indwelling the stent, and the use of medication to reduce the risk of possible complications associated with the use of a stent.

WITH OR WITHOUT STENT?

EnDCR procedure followed by stenting is widely and routinely used by practicing surgeons, but many studies have shown the same favourable outcome of the procedure without the use of stenting.

Over the last ten years, most of the studies on enDCR have been conducted with the objective to compare and evaluate the results with and without stent. We reviewed six published studies that fit the following criteria: clinically relevant trials on adult patients with NLDO who underwent enDCR with silicone stent intubation or enDCR without silicone stent intubation (Table 1).

Mostly patients with epiphora symptoms were included in the studies. Patients who had nasal or lacrimal system trauma, oncology of the nasolacrimal system, nasolacrimal duct obstruction with stones, systemic and chronic diseases, were excluded. The studies mostly included chronic patients, except one (Yu *et al.* 2021) in which patients with acute dacryocystitis were compared with a control group. In that study, the participants were divided into two groups according to the following criteria: evaluated presence of epiphora, lacrimal system irrigation test, and endoscopical estimate of ostium of rhinostoma.

Researchers at five centres observed that stenting did not improve the outcome of the operation, and the results of the follow-ups were similar (Al-Qahtani *et al.*, 2012; Chong *et al.,* 2013; Longari *et al.,* 2016; Yu *et al.,* 2021; Cavaliere *et al.,* 2022). One study did not find a statistically significant advantage of using enDCR with a stent over enDCR without one (Al-Qahtani, 2012). Also, there was no significant difference in the time of occurrence of granulations in these groups (Chong *et al.,* 2013).

Table 1. Summary of the characteristics of included studies

Study/ Year	Study design	Cases	Mean follow-up (months)	Stents removed (months)	Outcomes measured	Success rate with stent	Success rate without stent	Conclusion	Country
Al-Qahtani, 2012	RCT	173	12	4	Success rate	96% 89/92*	91% 73/81*	Low evidence to support the use of stent to improve surgical outcomes	Saudi Arabia
Chongo *et al.*, 2013	RCT	118	12	2	Success rate, complications	96.3% 52/54*	95.3% 61/64*	Silicone intubation did not affect the outcome and time to granulation tissue development	China
Fayers and Dolman, 2016	RCT	300	12	av. 3 (2–175 days)	Success rate, complications	94.7% 144/152*	87.8% 130/148*	Higher success rate in enDCR with stent	UK
Longari *et al.*, 2016	RS	89	18	2	Success rate, complications	82.2% 37/45*	88.6% 39/44*	enDCR without stent should be the first choice of procedure	Italy
Yu *et al.*, 2021	RCT	49	12	3	Success rate, complications	90.9% 20/22*	92.6% 25/27*	Do not recommend the routine stent intubation of AD	China
Cavaliere *et al.* 2022	RCT	60	av. 48 (12–72)	av.4 (3–6)	Success rate, complications	97% 29/30*	90% 27/30*	No benefit of stent in enDCR, it increases risks of restenosis	Italy

RS, retrospective study; RCT, randomised controlled trial; AD, acute dacryocystitis

* Eye rate of total numbers

Fayers and Dolman set a goal of stenting during enDCR to prevent failure from stenosis and fibrosis of the mucosal tissue at the common internal punctum, where the canaliculi enter the lacrimal sac or at the entrance to the nose because of adhesions between the sac edges or postsurgical adhesions between the turbinates and the ostium. On the other hand, disadvantages of stenting are complications that may occur due to the stent, the cost of the stent, the additional procedure time needed to place the stent, and the time and cost of instruments needed to remove the stent after the operation. The results of this study demonstrated that stenting increases the success rate (Fayers and Dolman, 2016).

However, it has been reported that enDCR without silicone stent intubation should be the first-choice procedure, and that stenting should be reserved for cases, when the surgeon finds common canalicular stenosis preoperatively or detects it intraoperatively (Longari *et al.,* 2016).

The necessity of silicone tube intubation was assessed in acute dacryocystitis (AD) in patients undergoing enDCR and the difference in success rate among groups was not significant (Yu *et al.,* 2021). Cases of failures in both groups were attributed to excessive fibrous and/or granulation tissue formation proximal to the ostium. However, granulation tissue formation rates were significantly higher in patients that had undergone silicone tube stenting, and this tissue formed earlier than in not stented patients (Yu *et al.,* 2021). This could be explained by the inorganic nature of stents or a "foreign body" effect that caused inflammation resulting in granulation tissue formation. A potential explanation might be also mechanical tissue friction, as even eye blinking makes stents move, thus leading to granulation tissue formation.

No statistical difference in the success rate was found also in another study (Cavaliere *et al.,* 2022), where despite one of major indications for stent placement being to impede fibrous stoma closure during healing, on long-term follow-up, patients with stents had a higher risk of re-stenosis after stent removal. However, the follow-up period was the longest (14 months), which may explain why restenosis was observed. Thus, they advised to insert stents for properly selected patients with worse anatomical and clinical conditions, such as fibrotic lacrimal sac or with purulent discharge, deviation of nasal septum that narrows the space, and trauma during the surgery (Cavaliere *et al.,* 2022).

A meta-analysis showed that currently there is no consensus on indications and duration of stent intubation, and there is no benefit in stenting for enDCR (Yim *et al.,* 2020). However, some studies showed a somewhat better success rate of the outcome of the procedure when using a stent (Fayers and Dolman, 2016).

In Latvia, no clinical studies on stent use in enDCR have been done, but in the near future we will compare patients who received enDCR with or without a silicone stent in order to assess stent requirements and duration.

In our own opinion and surgical experience in enDCR, a silicone stent should not be used in all cases. We insert stents in the following anatomical conditions: purulent content in the lacrimal sac, very narrow lacrimal sac, lacrimal punctum stenosis, and accompanying nasal septal resection surgery. During the last eight years, a total of 233 enDCR operations have been done in our clinic, with only eight re-exploration cases due to restenosis of stoma. Absence of a stent did not worsen the outcome of the operation.

WHAT KIND OF STENT MATERIAL SHOULD WE USE?

Over the history of stenting, many different types of stent materials have been used — metal, synthetic, organic. A perfect stent must have all of the following characteristics: inert and malleable, smooth external surface, cheap enough for everyone to afford it, as well as easily available. The silicon stent, that was displayed by Keith in 1968 had almost all of the required characteristics mentioned above. That is why primarily silicone stents are being used nowadays. Typically, for enDCR various modifications of bicanalicular silicone stents are used — Guboir, Ritleng, Bika, Crawfold, and O`Donoughue. Commonly, silicone stents are tubings with a patent lumen made from an elastic material. Many diverse variations of stenting equipment are used worldwide (Singh, 2015). Studies have not shown significant difference in success rates between different styles of silicone tubes (Kaçaniku *et al.,* 2018). Given that the stent material is elastic, softer and thinner, it is possible to avoid the cheese-wiring effect (Gibbs, 1967). A recent prospective randomised study (Okuyucu *et al.,* 2015) compared the effectiveness of different stents: *Prolen* (polypropylene), silicone otologic ventilation T-tube and silicone stent (Okuyucu *et al.,* 2015). The silicone was found to be the most effective (87.5%), followed by polypropylen (84.4%) and T-tube (62.5%). Efficiency in enDCR was high for both anatomical and functional success rate of prolene and silicone stents, and lower for otologic T-tubes. However, the polypropylene type stent was associated with orbital complications, such as canalicular laceration, conjunctivitis and corneal opacification as long-term complications. In spite of all these complications, polypropylene stents sometimes are still being used as an alternative to silicone due to their lower price. To avoid these complications, prolene stents should be carefully inserted and well fixed, otherwise they might scratch conjunctiva and cornea. Spontaneous loss of a stent less than three months postoperatively was only noted in otologic T-tubes.

USE OF ADJUNCTIVE TOPICAL MEDICATION

Mitomycin C (MMC), topical steroids like nasal spray, intralesional steroid injection (ISIs) or steroid eye drops, antibiotic eye drops, and silver nitrate application are used perioperatively to reduce the incidence of complications and to improve the results of surgical intervention. Therefore, we reviewed literature on medication to evaluate their effi-

ciency, with the aim that the results would allow a surgeon to make the best choice of medication in enDCR surgery.

Mitomycin-C. MMC is a chemotherapeutic agent isolated from *Streptomyces caespitosus,* which inhibits the synthesis of protein, DNA and RNA, by suspending the production of collagen by fibroblasts (Wakaki *et al.,* 1958). It is used during the procedure as an application in the stoma area, with soaked cotton swabs or gauze. Dosage of MMC is 0.2 and 0.5 mg/ml and exposure time is 2 to 15 minutes.

There is lack of studies on the use of MMC in enDCR, however one meta-analyses postulates that the use of MMC in DCR stoma could suppress the development of scarring and granulation around the stoma (Cheng *et al.,* 2013). The application of MMC in enDCR procedure is safe and the incidence of complications is at a relatively low level. The disadvantages of MMC are delayed wound healing and high medication cost. Thus, MMC can be a quite effective medication in certain situations like revision enDCR (Yim *et al.,* 2021).

Although MMC is registered in Latvia, it has not been used in enDCR procedures because it is too expensive; therefore, we lack experience in the use of this medication.

Steroids. There is a limited data pool of evidence-based studies on the effectiveness of adjunctive steroids in enDCR. However, those are widely used in the form of eye drops that are administered routinely after insertion of a stent. Unfortunately, relevant studies have not included a control group. Intralesional steroid injections (ISIs) definitely provide a good result in the treatment of postoperative granulomas, if they do not resolve spontaneously (Jo *et al.,* 2018). Also, a positive result can be attained by administration of topical nasal steroids to decrease the formation of granulation tissues (Ali *et al.,* 2015b).

In our practice we administer topical eye drops with steroids and antibiotics routinely in the postoperative period, being cautious in patients with glaucoma, and monitoring of intraocular pressure is conducted. In our practice, after enDCR, steroids are required only in some cases. We decide whether to use topical steroids during the follow-up endoscopy in patients prone to stoma restenosis or granulation tissue formation.

Antibiotics, biofilms and flora. The greater part of studies on perioperative use of antibiotics are descriptive in nature and outline institutional practices and outcomes. The critical evaluation of antibiotic prophylaxis is circumscribed by a lack of studies, small sample sizes, low overall infection rate, and the overall heterogeneity in surgeon-reported practice pattern (Yim *et al.,* 2021). However, infection of the lacrimal drainage system after enDCR with stenting is one of the most common complications (Ricca *et al*., 2018). It is associated with inflammation that is triggered by foreign material, and also stent is a nidus for microorganisms.

A study in Korea examined the results of 39 silicone stents inserted during DCR, which were removed at a median of five months (Kim *et al.,* 2012). The patient group who underwent enDCR was very small — 12.8%; the other patients underwent exDCR — 87.2%. Positive cultures were obtained in 94.9% of the 39 examined stents; 73.1% had Gram positive bacteria, 23.1% had Gram negative bacteria and in 3.8% fungi were detected. *Staphylococcus aureus* prevailed in the group of Gram-positive bacteria, *Pseudomonas aeruginosa* in the group of Gram-negative bacteria, and *Aspergillus sp*. among fungi. *Pseudomona aeruginosa*, which was identified in 12.8% of cases in this study, is a major pathogen microorganism of nosocomial and opportunistic infections. *Pseudomona aeruginosa* was mostly found in cases of purulent discharge at extubating or earlier removal of the stent due to purulent inflammation. This also correlated with unsuccessful surgical outcome. The most unfavourable postoperative period, associated with formation of granulation, membranous obstruction, or recurrent canalicular stenosis, involved longer indwelling of stent, and these cases were the most vulnerable to virulent *Pseudomona aerouginosa.*

In a similar study in India (Ali *et al*. 2013) on 50 stents removed three months after DCR, the share of enDCR also was small — 16%. Bacterial microflora was observed in 88% of cases, fungi in 60%, and 6% cultures were sterile — a mixed bacterial and fungal flora was identified in 48%. The most common Gram-positive bacteria was *Staphylococcus aureus* (18%), and *Pseudomonas aeruginosa* (27%) among Gram-negative, ranked by number of cases. Unlike the previous study, correlation was not found between the growth of *Pseudomona aeruginosa* and unsuccessful outcome of the operation. The huge proportion of fungal species isolated in the cases is explained by the geographical location and climatic conditions of the study. The humid tropical climate supports a higher rate of fungal spores in the inhaled air. It is thus possible that these fungi were commensal in the nasal cavity of these patients, or that the stent acted like a nidus for environmental fungi via inhaled air (Ali *et al.,* 2013).

In electronic microscope examination of the stents, extracted no earlier than one year after DCR and compared to the sterile stents, it was concluded that higher density, thickness and size of biofilms and deposits was related to a longer stent indwelling period (Ali *et al.,* 2015a).

In a study in California, pathogens and biofilms were observed to be responsible for clinically significant infection of silicone stents implanted within the lacrimal drainage system (Samimi *et al.,* 2016). In that study, the stents were removed early due to infection and sent for laboratory testing. The control group consisted of stents without signs of infection, which were routinely removed in five months. Decrease of epiphora was noted in 100% of patients without signs of infection, but only in 22% of patients with infected stents. Gram-positive and Gram-negative organisms were isolated from cultures of both infected and noninfected stents. Fungi were not found in either cohort. Conspicuously, mycobacteria species were found in 90% of infected stents, while in control group being singularly absent. In

South Florida, nontuberculous mycobacteria is the primary pathogen that causes clinically significant stent infection in the lacrimal drainage system (Samimi *et al.,* 2016). Reported differences in organisms isolated from explanted silicone lacrimal stents may highlight the variability in worldwide geographic flora and the difference between organism growth after external and endoscopic DCR (Samimi *et al.,* 2016).

The risk of infection can be decreased by the use of antibiotics corresponding to the pathogen, and by a shorter time of stenting. Further studies are needed to determine the prevailing flora and biofilms associated with geographic location and climatic zone.

In our practice, we use oral antibiotics for seven days only in concurrent surgery cases like septoplasty, when the patients have silicone splint indwelled. Of course, a single dose of antibiotics is given during the operation for all patients with enDCR with or without silicone stent. Topical antibiotic eye drops are applied in the first seven days after surgery in all patients of both variants.

Silver nitrate. In a study on the effect of silver nitrate exposure on enDCR outcome (Cetin *et al.,* 2022), 155 patients were divided into three groups: (I) the control group included 54 patients who received nothing during the enDCR, (II) group of 51 patients who received silicone stent for a two-month period, and (III) group of 50 patients underwent only application of silver nitrate. After a 12-month period, there was no significant difference among the groups in anatomical success: I – 94%, II – 92%, and III – 96%. In the silver nitrate group, peristomal granulation was observed only in one case, while in the stented group it was identified in eight people, and in four cases in the control group. The formation of granulation of the nasal ostium most often contributes to cicatricial stenosis or bone neogenesis. Silver nitrate is a low-cost medicine that successfully reduces the formation of granulation after enDCR (Cetin *et al.,* 2022).

In our practice, we use silver nitrate after the procedure in cases when we observe granulation tissue around the ostium of rhinostoma. Positive results after silver nitrate treatment are apparent – granulation subsides after several applications.

REMOVAL OF STENTS

The timing of stent removal in all the studied cases ranged from two months to 21 months. Only a few studies mentioned that stents had to be removed earlier due to infection of the lachrymal drainage system. It is not clear what determines the choice of the duration of stent indwelling. We found only one RCT study on early stent removal, but unfortunately it was for patients who underwent exDCR (Limbu *et al.,* 2019). In that study, 31 patients who completed 3-months follow-up were analysed: in group A the stents were removed two weeks after surgery, in group B the stents were removed after a standard six-week period. A success rate of 92.9% was found in group A, and 94.1% in group B group, with no significant difference.

Postoperative endoscopic control of stoma formation helps us make a decision on further patient management and possible early stent removal, thus preventing biofilm formation and other adverse events. There is also insufficient research on the duration of stent indwelling in enDCR.

In our own practice of silicone stent usage, we remove them after one month on average, guided by the outcome of the healing process that is endoscopically controlled. If stoma is well formed with no crusts and the bone is fully re-epithelised, the stent can be removed.

CONCLUSION

From the beginning of 2014 to February of 2022, we have performed 233 enDCR procedures, and in 198 cases a silicone stent was inserted during the operation in accordance with the recommendations in the literature. Since April 2018, in some cases, we did not insert a stent — this decision was based on new research data and accumulated surgical experience. By acquiring better surgical skills and more modern equipment, we were able to change the shape of the stoma with higher accuracy, which reduced the risk of stoma restenosis after the surgery. We still place a stent in the cases of simultaneous operations, narrow lacrimal canaliculi and the sac or a strongly thickened sac wall, which we detect intraoperatively. In our practice, stents are removed 3–4 weeks after the operation, when, during endoscopic examination of the nasal cavity, we observe that the healing process of the stoma is completed. The number of reoperations during this period was eight cases (3.43%) and the frequency has decreased in the last four years. This may indicate that the use of a stent does not affect the outcome of the operation. We plan to continue our work in this area and conduct a number of randomised trials in order to obtain more reliable data.

In this article we have tried to clarify the currently available issues regarding recommendations for stenting in enDCR. By applying a multidisciplinary and multi-staged approach in the development of evidence based clinical practice guidelines, it is possible to reduce the duration of the enDCR procedure, decrease associated financial costs and improve the quality of life for patients (AGREE Collaboration, 2003).

It may be advisable to use the stent selectively for recurrent procedures, narrow lacrimal sac, narrowing of the canaliculus or in situations when a tight common canaliculus opening is found during the surgery. This approach has been used in nonrandomised cohort study (Callejas *et al.,* 2010), where the indication for stenting was a tight Rosenmuller valve found during the procedure.

In the case when stent is inserted, we must minimise possible complications. The use of MMC and silver nitrate can

reduce the probability of granulation formation and stenosis of the stoma in the early postoperative period.

However, according to the literature, at present, there are no guidelines and no single point of view on indications for silicone stent insertion, and also there is no consensus regarding when to remove the stent. Major issues in the field are still:

- indications for use of stent insertion,
- criteria for stent removal,
- what is the period of time that a stent can remain with minimal complication risk,
- need of adjunctive topical treatment after enDCR — what exactly and in which cases.

Further multicenter studies are needed to decrease heterogeneity and provide better recommendations on these issues.

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STENTĒŠANAS LOMA ENDONAZĀLAJĀ DAKRIOCISTORINOSTOMIJĀ: PAŠREIZ PIELIETOTĀ TEORIJA UN AR TO SAISTĪTIE DAUDZIE IZAICINĀJUMI

Dakriocistorinostomas (DCR) standarta procedūra paredz, ka šīs operācijas laikā tiek veikta rutīnas stentēšana. Tās ilgums saskaņā ar dažādiem avotiem svārstās no sešām nedēļām līdz sešiem mēnešiem vai pat ilgāk (līdz 12 mēnešiem). Stenta ievietošana palīdz noformēties rinostomai un novērš tās stenozi. Kopš šīs metodes ieviešanas tikuši veikti daudzi pētījumi, lai analizētu DCR rezultātus ar stentu un bez tā, materiālus, no kuriem stenti tika izgatavoti, kā arī to, cik agrīni stentu drīkst evakuēt pēc operācijas. Pašlaik nav skaidru vadlīniju par stenta lietošanu un nav norādījumu par pēcoperācijas ārstēšanu. Tika analizēti vairāki pētījumi šajā jomā, izmantojot *PubMed* literatūru pēdējo desmit gadu laikā. Par konkrēto tēmu tika atlasīti galvenokārt randomizēti kontroles pētījumi (RCT) un retrospektīvi pētījumi (RS), kuros tika salīdzināti DCR rezultāti ar un bez stenta, kā arī stenta turēšanas ilgums, medikamentu lietošana komplikāciju riska mazināšanai, kas saistītas ar stenta pielietošanu. Salīdzinot pacientus ar vai bez stenta pēc endonazālās dakriocistrinostomijas (enDCR), tika iegūti vienlīdz labi rezultāti. Tomēr stenta lietošana dažkārt ir saistīta ar vairākām komplikācijām: granulāciju veidošanos agrākā pēc operācijas periodā, asaru drenāžas sistēmas infekciju, asaru kanāliņu plīsumiem. Mitomicīna C (MMC), lokāli lietojamo steroīdu un antibiotiku, kā arī sudraba nitrāta aplikācijām ir atšķirīga ietekme iepriekš minēto komplikāciju samazināšanā. Ir nepieciešami turpmāki pētījumi un to analīze, lai izstrādātu precīzākas indikācijas stenta pielietošanai enDCR laikā, ir jāizvērtē laiks, cik ilgi turēt stentu ievietotu pirms izņemšanas, kā arī papildu lokālu medikamentu lietošanas nepieciešamība, lai samazinātu iespējamo pavadošo komplikāciju risku.