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Optimal Repair and Stent Remove Time for Monocanalicular Laceration Repair with Mini-Monoka Stent

Kanalikül Yaralanmalarının Mini-Monoka Tüp ile Onarımında İdeal Cerrahi ve Tüpün Çıkarılması İçin Uygun Zamanlama

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ABSTRACT Objective: To evaluated the experience of canalicular repair using Mini-Monoka stent and assess the ideal timing of surgery and tube removal. **Material and Methods:** The forty-six patients who underwent canalicular laceration repair with Mini-Monoka stent were retrospectively reviewed. Demographics, type of injury, associated ocular injury, length of time between injury and surgery, the retention time of stent, functional, and anatomic success rates were analyzed. The effect of stent removal time on success rates and whether early removal of the stent has an impact on surgical success was evaluated. To assess whether the duration of time between injury and surgery affects surgical success, patients were divided into 3 groups according to the surgical repair timing which is 24 hours, between 24-48 hours, or after 48 hours. **Results:** The mean age was 30.6±16.7 with male predominance (80.4%). The mean duration from injury to surgery was 38.7±28.9 hours (2 hours-9 days). The stent was removed on average at 6.7±1.86 (2-9) weeks. Early removal of the stent was not associated with failure cases. Anatomical and functional successes were 84.7% and 89.1%, respectively. There was no significant difference between anatomical (p=0.78) and functional success rates (p=0.12) based on the repair timing among the above-mentioned three groups. **Conclusion:** With an elective scheduling surgery, instead of an urgent repair, it is possible to achieve high success rates with an experienced team under appropriate conditions. The retention time of stent at 7 weeks on average may be adequate to provide canalicular patency.

Keywords: Canalicular laceration; Mini-Monoka; surgical repair timing; timing of stent removal

ÖZET Amaç: Mini-Monoka tüp entübasyonu ile kanalikül onarımı yapılan olguların klinik sonuçlarını bildirmek ve ideal cerrahi ve tüp çıkarılma zamanlamasını değerlendirmektir. **Gereç ve Yöntemler:** Kanalikül kesisi nedeni ile Mini-Monoka silikon tüp entübasyonu ile kanalikül onarımı yapılan 46 hastanın kayıtları geriye dönük olarak incelendi. Hastaların demografik özellikleri, yaralanma şekli, eşlik eden oküler yaralanma, yaralanma ile cerrahi arasında geçen süre, silikon tüpün çıkarılma zamanı, anatomik ve fonksiyonel başarı oranları kaydedildi. Silikon tüpün çıkarılma zamanının cerrahi başarı üzerine etkisi ve tüpün erken çıkarılmasının cerrahi başarıyı etkileyip etkilemediği değerlendirildi. Cerrahi için geçen sürenin cerrahi başarı üzerine olan etkisin değerlendirmek amacıyla ilk 24 saatte, 24-48 saat arasında ve 48 saatten sonra opere edilen olgular arasındaki başarı oranları karşılaştırıldı. **Bulgular:** Hastaların %80,4'ü erkek olup, ortalama yaş 30,6±16,7 yıl idi. Kanalikül yaralanması ile cerrahi arasında geçen süre ortalama 38,7±28,9 saat (2 saat-9 gün) idi. Silikon tüpün kalış süresi ortalama 6,7±1,86 (2-9) hafta idi. Tüpün erken çıkarılmasının cerrahi başarısızlık ile ilişkili olmadığı saptandı. Ortalama anatomik başarı %84,7, fonksiyonel başarı ise %89,1 olarak saptandı. İlk 24 saatte, 24-48 saat arasında ve 48 saatten sonra opere edilmiş olan hastalar arasında anatomik (p=0,78) ve fonksiyonel (p=0,12) başarı açısından istatistiksel anlamlı fark izlenmedi. **Sonuç:** Mini-Monako tüpün ortalama 7 hafta kalması kanaliküler açıklığın sağlanmasında yeterli olabilir. Acil bir onarım yapmak yerine, uygun koşullar altında, deneyimli bir ekip ile planmış olan cerrahi ile yüksek cerrahi başarı oranlarına ulaşmak mümkündür.

Anahtar Kelimeler: Kanalikül yaralanması; Mini-Monoka tüp; cerrahi onarım zamanı; tüpün çıkarılma zamanı

The canalicular laceration is the most frequently encountered lacrimal system trauma due to lack of connective tissue support.[1,2] Previous studies reported that canalicular laceration constitutes 16%-36% of all eyelid laceration.[3,4] Children and young adults are the most frequently affected besides, the lower canalicu-

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lus is especially vulnerable regarding direct or indirect ocular injuries.[1,2,4-7] Proper management of the lacerated canaliculus is required to restore proper eyelid anatomy and to prevent canalicular stenosis and blockage of lacrimal pathway.[5,7,8] The need for repair of single canalicular laceration is still controversial, but there are studies reported that tear flow is generally similar in both canaliculi and physiological restoration of tear flow and this is best in case where both canaliculus work well.[9,10] Most researchers suggested that all canalicular lacerations need to be repaired with temporary canalicular stents to a void fibrosis and subsequent stenosis and thereby can maintain its patency.[10-13]

The Mini-Monoka stent (FCI Ophthalmics, Marshfield Hills, MA, USA), is widely used for canalicular repair because it is easy to insert, does not require additional fixation, can shorten operative time and it prevents bicanalicular stents complications.[4-6,8] Although the high success rate of the repair of canalicular laceration with using Mini-Monoka stent has been reported, timing of repair and tube removing time are still the most controversial issues. This study aimed to describe surgical outcomes of a single canalicular laceration with Mini-Monoka stent, to discuss the timing of the canalicular repair and to evaluate whether early removal of the tube affects surgical success.

MATERIAL AND METHODS

In this cross-sectional study, medical records of all consecutive patients who underwent primary single canalicular laceration repair with Mini-Monoka stent at Ulucanlar Eye Research Hospital from April 2016 to March 2021 were retrospectively analyzed. Informed consent was obtained from each subject. The study was approved by Ankara Training and Research Hospital Clinical Research Ethics Committee (date: February 20, 2020, no: 167). Declaration of Helsinki was followed throughout the study. The patients with a lack of adequate follow up (less than 12 months) and unreachable patients for follow-up evaluations were excluded from the study. The collection of data has consisted of demographic profile of the patients, type of injury, duration from injury to surgery (repair time), associated ocular injuries, surgical outcomes, premature stent extrusion, and timing of stent removal, stent-related complications, and anatomical and functional success rates.

Anatomical success was defined as a patent lacrimal sac irrigation with saline while functional success was described as the absence of epiphora at the last visit after stent removal. For the pediatric population, if the patients did not allow the lacrimal irrigation in office, anatomical success was defined as negative fluorescein dye disappearance test. Munk score that ranges from 0 (no watering) to 4 (constant watering) was obtained from every patient and the parents of the pediatric patients (Table 1). Additionally, functional success was determined as Munk of 0. We divided the patients into three groups as Group 1, 2 and 3 according to the time of operation after injury, respectively: the operations occurred for the former group in the first 24 hours, for the latter one between 24-48 hours, and for the last group after 48 hours. Functional and anatomic success rates were compared among these groups in order to evaluate the effect of time of operation on surgical success.

OPERATION PROCEDURES

In all cases, operation procedures underwent repair of canalicular laceration in an operating room under local, sedation or general anesthesia by oculoplastic specialists (FCE and ES). Surgical intervention was performed which includes identification of cut ends of canaliculus with the aid of microscope and placement with Mini-Monoka stent. The most challenging aspect of the surgery was to identify the distal cut end of the canaliculus especially if the laceration was deep and near the junction of lacrimal sac. If direct inspection of the pinkish tubular canalicular mucosa tissue was not adequate to recognize, we used diluted povidone-iodine or pigtail probe irrigation through opposite punctum to facilitate identification of the cut

TABLE 1: Munk score.

Grade 0	No epiphora
Grade 1	Occasional epiphora, requiring dabbing less than twice a day
Grade 2	Epiphora requiring dabbing 2-4 times per day
Grade 3	Epiphora requiring dabbing 5-10 times per day
Grade 4	Epiphora requiring dabbing more than 10 times per day

ends of the lacerated canaliculus. When distal and proximal end of laceration could be identified, the punctum was dilated with the small-gauge punctum dilatator. Afterwards, Mini-Monoka stent was inserted with its distal end passing into the lacrimal sac and the proximal end was fixed over the punctum. Finally, pericanalicular sutures with 8-0 polyglactin suture were placed to fix and maintain the lacerated canaliculus. Additionally, the associated eyelid laceration was repaired with 6.0 polyglactin suture.

STATISTICAL ANALYSIS

The SPSS software (version 21.0, IBM, Chicago, IL, USA) was used for statistical analysis. Descriptive statistics, including the mean, standard deviation and range were calculated for different variables. Fischer's exact test was used to analyze clinical outcomes. A p-value less than 0.05 was considered statistically significant.

RESULTS

The forty-six patients met the inclusion criteria who underwent repair of canalicular lacerations using Mini-Monoka stent were included in the analysis. The mean age was 30.6±16.7, the median age was 31.5 (range: 2-69 years), and 9 (19.6%) of the patients were younger than eighteen years. Out of 46, 37 patients were male (80.4%) and 9 patients were female (19.6%). None of them had a bilateral canalicular laceration. Details of the demography, including the type of injury and associated ocular injuries, were listed in Table 2. The most common etiology was blunt trauma (31 patients, 67.4%). Simultaneous eyelid laceration was the most associated ocular injury (63%). In addition, we found hyphema in 1 patient (2.2%), orbital fractures in 3 (6.5%), conjunctival tear in 3 (6.5%) and sclero-corneal tear in one case (2.2%). A total of 8 patients (17.4%) had concurrent globe injury which 4 of them had upper canaliculus, and 4 of them had lower canaliculus involvement. The lower canaliculus was involved in 36 (78.3%) and upper canaliculus in 10 (21.7%) patients. The right eye (n=27; 58.7%) was affected in most of the patients, and the right lower canaliculus was the most common site of injury. The surgical outcomes of the patients were summarized in Table 3. The mean duration from injury to surgery was 38.7±28.9 hours and was repaired at the earliest 2 hours and at the latest 9 days later. The mean follow-up period was 13.67±2.4 months (12-21 months). The stent was remained in place for 2 to 9.3 weeks (mean: 6.7±1.86 weeks). There was no correlation between duration of stent and anatomical (r=0.113, p=0.513) and functional (r=0.096, p=0.577) success rates. We found that early removal of the stent did not relate to failure cases.

Anatomical and functional successes were 84.7% (39/46) and 89.1% (41/46), respectively. We also investigated the effect of operation time on sur-

TABLE 2: Demographic profiles of patients undergoing repair of canalicular lacerations.

Characteristics		Number (% or range)
Total number of patients		46
Mean/Median age		30.6±16.7/31.5 (2-69 years)
Male/Female		37 (80.4%)/9 (19.6%)
Mode of injury	Blunt injury	31 (67.4%)
	Traffic accident	6 (13%)
	Fall-related	4 (8.7%)
	Sharp object	3 (6.5%)
	Animal attack	2 (4.3%)
Associated ocular injury	Eyelid lacerations	29 (63%)
	Hyphema	1 (2.2%)
	Orbital fractures	3 (6.5%)
	Conjunctival tear	3 (6.5%)
	Sclero-corneal tear	1 (2.2%)

TABLE 3: Surgical outcomes of patients undergoing canalicular repair.

		Number (n or %)
Right/Left eye		27 (58.7%)/19 (41.3%)
Canaliculus involvement	Lower	36 (78.3%)
	Upper	10 (21.7%)
The mean time between injury and repair		38.7±28.9 hours (2 hours-9 days)
Type of anesthesia	General	17.4% (n=8)
	Sedation	15.2% (n=7)
	Local	67.4% (n=31)
The mean time of stent removal		6.7±1.86 weeks (2-9.3 weeks)
Anatomic success		84.7% (n=39/46)
Functional success		88.9% (n=41/46)
The mean follow-up period		13.67±2.4 months (11-21 months)

gical success. The anatomic and functional success rates of 19 patients who were operated within the first 24 hours (Group 1), 15 patients who were operated between 24-48 hours (Group 2), and 12 patients who were operated after 48 hours (Group 3) were compared. As shown in Table 4, whereas there were no statistically significant differences regarding anatomical and functional success rates according to repair timing among the three groups (p=0.78 for anatomical success, and p=0.12 for functional success), both anatomically and functional success rates were clinically higher in patients who were operated between 24-48 hours. There was also no difference between those who were operated within the first 48 hours and after 48 hours (p=0.75 for anatomical success, and p=0.61 for functional success, Fisher's exact test). We found that there was no correlation between injury time and anatomical (r=-0.074, p=0.669) and functional (r=-0.20, p=0.910) success. Moreover, prolonged surgical time did not have decreasing effect on surgical success rates.

None of the patients had eyelid malposition after removal of the Mini-Monoka stent, including ectropion and entropion. Early stent extrusion was the only complication related to the stent. Spontaneous premature stent extrusion was observed in two patients at 7th and 15th days postoperatively. Two-year-old patient, who scratched his eye and caused early stent extrusion at 15 days, was examined under general anesthesia and showed that irrigation was patented. The other patient who had stent extrusion on the 7th day due to severe sneezing was re-repaired with the Mini-Monoka stent. In this patient, silicone stent was removed after 6th weeks after re-operation and both anatomical and functional success were achieved.

TABLE 4: Anatomical and functional success rates according to repair timing.

	Anatomical success		Functional success	
	n	(%)	n	(%)
Group 1 (n=19)	16/19	(84.2)	18/19	(90)
Group 2 (n=15)	13/15	(88.8)	13/15	(93.3)
Group 3 (n=12)	10/12	(83.3)	10/12	(83.)
*p**	*0.78*		*0.12*	

*Significance at the 0.05 level, Fisher's exact test; Group 1: Operated first 24 hours, Group 2: Operated between 24-48 hours, Group 3: Operated after 48 hours.

The canalicular block was noted during lacrimal irrigation in 7 (15.2%) out of 46 patients at the final follow-up. It was observed that continuous watering in 3 patients and intermittent watering in 2 patients out of the 5 (10.9%) patients with greater than Munk of 1.

DISCUSSION

Mini-Monoka stent well-defined to repair of monocanalicular laceration, but there is no consensus on clear-cut optimal time of stent removal available in the literature.[13-16] Although there is no consensus on the exact duration of the Mini-Monoka monocanalicular stent to achieve long-term patency, majority of studies tend to propose longer duration. The usual durations in the literature are from 3 to 6 months. In the current study, Mini-Monoka stents were maintained for 6.7 weeks on average. This is the shortest stent duration time reported in the literature for the Mini-Monoka stent.[4,5,11,17,18]

In 1994, Conlon et al. designed an animal model to investigate the histology of canalicular lacerations after intubation.[19] They concluded that the optimum time for removal of the silicone tube was 12 weeks. However, the results of this study are completely unpredictable to human beings. Publications suggested that the ideal duration of the tube should be at least 3 months which is generally referred to this study.[4,12,15,18] In a retrospective study, Chatterjee et al. used a silicone rod as a monocanalicular stent and reported leaving the silicone rod in place for a mean of 6.9 weeks.[20] However, their anatomical success rate remained at 71.4%, and spontaneous extrusion of monocanalicular stent occurred 21.4% of patients. Their results probably related to the nature of the monocanalicular stent and its high rates of spontaneous extrusion. In our study, Mini-Monoka stents were maintained for 6.7 weeks on average. This is the shortest stent duration time reported in the literature for the Mini-Monoka stent and also any kind of canalicular stents.

Despite the shorter tube duration compared to previous studies, our surgical success rates (anatomical success, 84.7%; and functional success, 89.1%) are consistent with the literature. Our spontaneous

premature stent extrusion rate was 4.4% (2 patients), and besides, a 2-year-old patient who had early stent extrusion in two weeks was found patent irrigation without needed any surgical intervention. A faster wound healing response in children may have resulted in patency of injured canaliculus, although the silicone tube remained for two weeks. An electron microscopic study demonstrated increasingly deposits and extensive biofilms in Monoka stents that were retained for 3 months as compared with the ones retained for 6 weeks.[21] In the current study, the removal of the silicone tube in the 6.7th week on average provided the canalicular patency. Removal of the Mini-Monoka stent earlier than 3 months can prevent both stent-related complications and the harmful effects of the biofilm formation, as well as sufficient to maintain canalicular patency.

Numerous elements such as pediatric patients, systemic conditions, the complexity of trauma, healthcare access, anesthesia, and staff support are influential to decide the time of surgery. Additionally, an ophthalmic emergency doesn't apply for the adjustment of canalicular laceration. Therefore, there is no definite consensus on the convenient surgical time in literature. The recommended appropriate surgical time for canalicular repair has changed over time. Prior studies have suggested that canalicular repair should be performed within the first 6 hours and the repairs over 24 hours have been concluded with failure.[22,23] However, Hanselmayer demonstrated an equal success rate for the first 6 hours and 7-48 hours after laceration.[24] Since then, repair within first 48 hours has become a standard, but subsequent studies also have proven that successful surgical outcomes beyond 48 hours.[7,13,16-18] In addition, several recent studies have suggested that canalicular repair can be delayed for 7 to 11 days.[7,17,25] In the present study, the mean surgical timing was 38.7 hours and was repaired at the earliest 2 hours and at the latest 9 days later. We established that overall anatomical and functional success rates were found similar in the literature.[5,17,18,25-28]

Compared to the cases operated within the first 24 hours, between 24-48 hours and 48 hours later, we realized that anatomic and functional success rates were clinically higher in patients operated between 24-48 hours, even if not statistically significant, compared to those operated in the first 24 hours and after 48 hours. Chu et al. contrasted between early (surgery less than 48 hours after injury) versus late (surgery greater than 48 hours after injury) canalicular repair outcomes, as a result, they found no statistical difference in success rate (92.4%, 90.9%, p=0.73) between the groups.[13] There was also no difference in surgical success rates between those who were operated in the first 48 hours and 48 hours later in the present study same as the findings of Chu et al. Kennedy et al. revealed that there was no correlation between operation timing and postoperative epiphora.[13,29] We did not also establish any correlation between duration of injury and anatomical and functional success rates. Recent studies and our study have shown that success in late repair cases corresponds to early repair.[7,13,15-17,25,29] We have concluded that it is worthwhile to try and adjust the injured canaliculus at any time after injury. In place of performing an urgent repair, it is possible to achieve surgical success with an elective repair performed under appropriate conditions by an experienced team.

As noted in previous studies, canalicular lacerations are often seen in young adults and children.[4,11,15,17,18,29,30] Considering the dominance of a young population, the long life expectancy, and the possibility of future injury we may encounter, it would be wise to repair all canaliculus lacerations, even if there is single canaliculus involved.[4,7,15] In our study, the mean age of patients with canalicular lacerations were 30. 6 years old. However, the same was determined as 16 years old by Naik et al. and 19.3 years old by Alam et al. in the studies of India.[4,17] The other studies were reported that the mean age of patients with canalicular laceration was between 27 and 48 years.[6,8,13,15,16,18] These differences are probably related to the type of injury and diverse populations of studies. Two other studies of India have reported an injury that occurs with "blouse-hook fastener" in infants while breastfeeding has been identified as the most widespread cause with canalicular laceration.[4,17] Lin et al. found that the mean age of patients with canalicular lacerations was 38, which is more prevalent in men, besides, these results are substantially associated with motorcycle accidents in Taiwan.[8] In our

study, blunt trauma (67.4%) was the most prevalent etiology of canalicular injuries which two-thirds of them caused by occupational accidents and fight-related injuries. We found that canalicular lacerations were more prevalent in the male population (80.4%) which has been reported in previous studies and the mode of injury to explain the frequency of canalicular injuries for young adult men.[4,18,29]

Subsequently, previous studies indicated that the lower canaliculus is more prevalent for all canalicular lacerations. The incidence of lower canaliculus involvement in various series has been reported from 54.1% to 77.1%.[4-6,8,16-18] We demonstrated similarly to the literature that the lower canaliculus was more frequently affected (78.3%), and this is followed by upper canaliculus involvement (21.7%). There were no cases of bicanalicular laceration. Anatomically, the canalicular system, which is not supported by the tarsus and is relatively weak, is vulnerable to eyelid injuries. It was suggested that medial canthal lacerations occur more prevalent for children and young adults with involving frequently the lower canaliculus.[2,7]

Earlier studies have been reported a close relationship between upper canalicular lacerations and co-existing globe injuries (from 20% to 25%).[4,30] They stated that if there is an upper canalicular injury, the index of suspicion should be increased for an injury to the globe. In our study, 8 (17.4%) patients had concurrent globe injury which 4 of them had upper canaliculus, and the rest had lower canaliculus. Despite the literature, rate of lower and upper canalicular injuries has been similar in patients with simultaneous globe injuries in our series. This highlighted the vitality of being aware and management of co-existing eye injuries for the whole canalicular lacerations.

The present study limited by being retrospective design, the low sample size, and relatively short follow up. Because of the retrospective nature, the main concern of the study is that we were not to define the exact cut-off time for early stent removal. Although the current study demonstrated the removal of the silicone tube in the 6.7th week was adequate, removal of the stent much earlier could also provide the canalicular patency. To prove it, there is a need for a larger scale prospective study.

CONCLUSION

The current study demonstrated that leaving the stent in place for 7 weeks on average maintained the canalicular patency. Contrary to previous reports, the removal of the Mini- Monoka stent earlier than 3 months can be considered to provide canalicular opening and to avoid potential stent-related complications. Even if delayed cases, a repair under appropriate conditions by an experienced surgical team can be achieved to surgical success.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Fatma Çolak Eroğlu;* ***Design:*** *Fatma Çolak Eroğlu, Emine Şen;* ***Control/Supervision:*** *Fatma Çolak Eroğlu, Emine Şen;* ***Data Collection and/or Processing:*** *Fatma Çolak Eroğlu, Emine Şen;* ***Analysis and/or Interpretation:*** *Fatma Çolak Eroğlu, Emine Şen;* ***Literature Review:*** *Fatma Çolak Eroğlu, Emine Şen, Burcu Kazancı;* ***Writing the Article:*** *Fatma Çolak Eroğlu;* ***Critical Review:*** *Fatma Çolak Eroğlu, Emine Şen, Burcu Kazancı;* ***References and Fundings:*** *Fatma Çolak Eroğlu;* ***Materials:*** *Fatma Çolak Eroğlu, Emine Şen.*

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