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Medial canthopexy using mini-screws &/or micro plates for the surgical treatment of post traumatic telecanthus associated with naso-orbito-ethmoidal fractures

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ABSTRACT

Background: The normal bony insertion of the medial canthal tendon can be disrupted after trauma, as a result of ablative surgery or as a consequence of subperiosteal detachment during a craniofacial surgical procedure. Medial canthoplasty is required to avoid telecanthus following these events. Several surgical techniques have been described to reattach the tendon to the posterior lacrimal crest. The techniques of transnasal wiring had been used widely to reconstruct medial canthal tendon. However, some surgeons have preferred the use of ipsilateral techniques that include the nylon anchor suture, the stainless-steel screw and/or miniplates.
Aim of the study: This study aims to present a technique for Canthopexy and Medial canthal ligament reconstitution secondary to posttraumatic medial canthal degloving injuries using mini-screws and/or microplates to obtain a consistent and definitive reinforcement of the Medial Canthal ligament and its continuity to the postero-superior surface of the medial orbital wall.
Materials and methods: The present study enrolled 23 patients with posttraumatic medial telecanthus deformity that had been treated over a 3-year period from July 2016–June 2019. Clinical examination had been scheduled for all patients regarding evaluation of lacrimal system function, medial canthal position in addition to eyelid measurements. Visual impairment and movements of the eye were evaluated by ophthalmological consultation. Irrigation and probing were used for evaluation of the nasolacrimal system. MCT detachment can be determined by Bowstringing test through subcutaneous palpation of the MCT as one stretches the lid laterally.
Eyelid evaluation comprised recording measurements of the inter-canthal distance (ICD), the interpupillary distance (IPD) and the palpebral fissure length (PFL). Telecanthus was assessed by recording the distance (in millimetres) measured between the facial midline and the medial canthus of the injured eye that will be compared to the corresponding values of the uninjured eye preoperatively and at all postoperative follow-up intervals. Radiographic assessment was evaluated by axial, coronal and sagittal C.T scans preoperatively and at 1, 3 and 6 months postoperatively.
Results: Medial Canthopexy with mini-screws was performed in 15 patients while a Y-shaped micro plate was utilized in 8 patients. The postoperative medial canthal position had been reported to be satisfactory in all patients, showing a considerable improvement compared with the preoperative position. The patients were re-evaluated at 1,3 and 6 months postoperatively demonstrating absence of any evidence of recurrence and with an acceptable cosmetic result, as the medial canthal concavity had been successfully achieved. All patients were satisfied except one that was overcorrected and re-operated for re correction. Another one was under corrected and had undergone revision. However, at 6 weeks postoperatively, one patient had a wound dehiscence resulting in medial canthal detachment and required retreatment. In all patients (except for the one of wound dehiscence), the post-canthopexy Bow String test failed to cause loss of canthal re-attachment and reconstruction or even lateral displacement of the medial canthal tendon throughout all the follow-up intervals.
Conclusions: Medial Canthopexy using mini-screws and/or microplates is a simple, easy and reliable technique for the surgical correction of posttraumatic Telecanthus secondary to MCT detachment as this technique promotes satisfactory post-surgical outcomes with resultant acceptable esthetic and functional results.

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Introduction

The normal bony insertion of the medial canthal tendon can be disrupted following Midfacial traumatic injuries, as a result of tumor ablative surgery or as a consequence of subperiosteal detachment following craniofacial surgical procedures [1].

Medial canthal injuries had been generally categorised into two main types: degloving soft tissue injuries and injuries associated with Naso-orbito-ethmoidal bony disruption or fractures. Naso-orbito-ethmoidal fractures may be also associated with soft tissue degloving injuries; however, adequate reduction and rigid fixation of the disrupted NOE bony component should precede any successful soft-tissue reconstruction. On the other hand, pure Soft-tissue degloving injuries are not usually associated with any concomitant bony disruption component. These degloving injuries usually result in disruption and detachment of the Medial canthal ligament along the medial canthus soft tissues secondary to shearing forces usually transmitted from the soft tissues of the eyebrow/forehead component propagated through the medial canthus to be transmitted to the lower eyelid/cheek component [2].

Injuries to the Naso-orbito-ethmoidal (NOE) complex with its anatomical co-partners principally the medial canthus, upper and lower eyelids, and nasolacrimal drainage system represents a challenge to both the Oral and Maxillofacial and plastic surgeons since it scores significant functional and aesthetic compromise. In order to successfully manage these degloving injuries, the surgeon must be adequately familiar with the applied anatomy of this region [1].

NOE fracture is a fracture of the central area of the facial skeleton where the orbits, nasal bones, maxilla, frontal bone, and anterior skull base coalesce. The key to diagnose a NOE fracture is the area where the medial canthal tendon is inserted and anchored to the medial orbital wall. Fracture of this area is known as NOE fracture [3].

Since the mid twentieth century, the most common cause of an NOE fracture was a motor vehicle accident (MVC) in which the patient's face struck the dashboard/steering wheel. Moreover, any high velocity blunt force trauma directed to the face can cause a NOE fracture [2].

Normal anatomy of NOE region

The normal bony anatomy in the NOE region is comprised by multiple bones. The frontal bone contributes to the orbital roof. The paired nasal bones interdigitate with each other in the midline and with the frontal bone superiorly. Most of the orbital floor is formed by the maxillary bone. The frontal process of the maxilla fuses with the nasal bones laterally and the frontal bone superiorly. The lacrimal bone constitutes mostly the medial orbital wall and corresponds to the key area in NOE fracture classification [3].

Surgical anatomy of the medial orbital wall

The Medial orbital wall is formed of a complex interdigitation of various bones of the Midfacial skeleton as well as several tendinous attachments for providing support to the eyeballs, eyelids and the lacrimal apparatus [4].

The medial wall of the orbit is approximately 5 cm in length and composed mostly of thin bones ranging from 0.2 to 0.4 mm in thickness. The ethmoid bone makes up most of the medial orbital wall beside participation of the lacrimal bone [5].

The Lacrimal bone with the maxillary frontal process constitutes the lacrimal fossa that encloses the lacrimal sac. The upper portion of the fossa is in contact with the anterior ethmoidal cells while the lower portion shares a common wall with the middle meatus. The anterior part of the fossa although formed by a bony ridge of the maxillary bone is referred to as the Anterior Lacrimal Crest, while the posterior bony ridge is called the Posterior Lacrimal Crest. The nasolacrimal duct passes through the lateral wall of the nose inferiorly to open in the inferior meatus. The connective tissues of the MCT medially and LCL laterally anchor the lids firmly in place. Both of which attach to the bony margin of the orbit behind the plane of the cornea. [6].

Surgical anatomy of the medial canthal tendon or ligament

The majority of the MCT is made up of the tendinous portions of the orbicularis Oculi muscle. The tendons of the orbicularis Oculi converge to be inserted medially into the medial orbital wall. The MCT is considered to be a tripartite structure formed of anterior, posterior, and superior limbs where the resultant vector of the 3 limbs points just superior and posterior to the anterior limb attachment [7].

The anterior limb is attached mostly to the anterior lacrimal crest/frontal process of the maxilla whereas the superior vertical limb is less securely attached along the maxillary frontal process and to lesser extent the frontal bone. The small posterior limb of the MCT is anchored to the posterior lacrimal crest. The tendon thus mounts the lacrimal sac acting as a pump squeezing excess tears inferiorly through the lacrimal duct [8, 9].

Functions

The MCT is considered as a part of the suspensory sling which functions to provide globe support and accordingly is in direct continuity with the lateral canthal ligament, and upper and lower tarsal plates [6].

The MCT is considered the medial extension of the tarsal plates. It is responsible for defining the traditional almond sloping configuration of the palpebral fissure. Constantly providing intimate contact of the eyelids against the curved configuration of the eye globes during lid blinking movements, the MCT acts as a hinge for eyelid function. As the tarsal apparatus is anatomically located in one surgical plane as the orbital septum, it passes from its lateral attachment at the Whitnall's tubercle, runs through the upper and lower tarsi, then ends into the MCT where it becomes inserted along the anterior and posterior lacrimal crest surrounding the lacrimal sac and fossa [8].

The MCT and therefore, the orbicularis oculi musculature function as a lacrimal pump, creating positive and negative pressure on opening and closing of the eyes and accordingly they ensure the free flow of tears from the puncta through the lacrimal system. Accordingly, the MCT structurally provides support to the lacrimal drainage system promoting the movement of fluid during eye blinking [10].

Pathology and mechanism of injury

Rupture of the medial canthal tendon (cut across) usually occurs as a result of sharp foreign body or by sharp bone fragment [11], surgery in the region as in tumor ablation or excision [12]. Avulsion of the medial canthal tendon usually results from sever blunt trauma associated with or following Naso-orbito-ethmoidal (NOE) fractures [13]. More often, the medial canthal tendon usually is not severed from the lacrimal bone but fracture displacement of bone structure supporting the MCL occurs. Such injuries are usually the result of Road traffic accidents and assaults [12].

Following avulsion of the medial canthal tendon (MCT), traumatic telecanthus usually develops and is demonstrated clinically by increase in the intercanthal distance (ICD) accompanied by shortening of the palpebral fissural length (PFL) together with roundation of the medial palpebral angle [13–15]. As a consequence of detachment of the medial canthal tendon, the resultant contraction of the orbicularis oculi muscle will further exaggerate the telecanthus deformity, palpebral angle and palpebral fissural length over time [8,16–18]. As a consequence, epiphora in addition to other functional derangements are the eventual suspected outcome.

In order to define the resultant bony and soft tissue canthal derangements. Various authors have reported on methods of measurements and normal distances, using palpitation and X-ray techniques.

The intra-orbital distance (IOD) or the distance between the bony medial walls of the orbit is usually less than 25 mm in the female and

28 mm in adult male. Distances vary with age, sex and there are intra-racial differences.

The inter-canthal distance (ICD) or the distance between the right and left medial canthi, can vary from 22 mm in infant to 32 mm in the adult and the telecanthus means increase in this distance more than half of the interpupillary distance.

The interpupillary distance (IPD) or the distance between the centre of the right and left pupils (in normal gaze) can vary from 60 to 70 mm in adults.

The outer canthal distance (OCD) is the distance between the right and left lateral canthi.

Approximation of normal can be obtained by recognizing that the intercanthal distance should be equal to the palpebral fissure length (PFL) and the canthus should be midway between the mid-sagittal plane of the nose and the centre of the pupil [19].

Successful and satisfactory repair of traumatic telecanthus had presented a challenge for Maxillofacial surgeons for decades. Achieving an acceptable aesthetic result for patients had been considered a difficult requisite as even minor drawbacks or defects can be readily discovered and recognized by others in the midfacial region [20].

In general, the aim of any Medial Canthopexy is to reduce the MCT medially as well as superiorly and posteriorly so that to restore the normal position of the eyelids corresponding to the curvature of the eyeball [21,22].

Early in the 20th century, various medial Canthopexy and Canthoplasty techniques had been advocated by Maxillofacial surgeons, Ophthalmologists and plastic surgeons in order to restore and reconstruct the MCT attachment. However, Secure bony fixation of the medial canthal structures remained a difficult surgical challenge [21–30].

The proper reconstruction and restoration of the MCT for achievement of accurate intercanthal distance, palpebral fissural length and medial palpebral angle, together with a satisfactory relation of the eyelid to the globe constitute the cornerstone of a successful reconstruction [22]. Various surgical techniques have been described in the past to achieve this goal, such as transnasal wiring [23,24], titanium screws [27], titanium miniplates cantilevered from the nose [21], commercially available anchoring systems [17,28], periosteal flaps [29], and medial tarsal strips [30]. However, several drawbacks had been attributed that lead to various complications such as skin necrosis, extensive transnasal dissections to the opposite orbit with resultant damage to the contralateral orbital structures and device exposure or extrusion [17,23–28].

Accordingly, the objectives of any medial canthopexy are restoration of natural inbred medial canthal angle and position along the anterior lacrimal crest, re-establishment of natural palpebral fissural length and shape, and preservation of normal palpebral function altogether without endangering the normal drainage of the lacrimal apparatus.

The present study will present and demonstrate a medial canthopexy technique to correct posttraumatic telecanthus by using mini-screws and/or micro plates applied through a rotational advancement upper eyelid myocutaneous flap developed by a Z-plasty incision.

Aim of the study

This study aims to present a technique for Canthopexy and Medial canthal ligament reconstitution secondary to posttraumatic medial canthal degloving injuries using mini-screws and/or microplates to obtain a consistent and definitive reinforcement of the Medial Canthal ligament and its continuity to the postero-superior surface of the medial orbital wall.

Patients and methods

The present study enrolled 23 patients with posttraumatic medial telecanthus deformity that had been treated over a 3-year period from July 2016–June 2019. Thirteen patients were treated at the Department of Cranio-Maxillo-Facial and Plastic Surgery, Faculty of Dentistry, Alexandria University, while Ten patients were treated at the Oral and Maxillofacial Surgery Department, Faculty of Dentistry, October 6 University, Egypt.

All patients who were considered indicated for medial canthopexy underwent the surgical technique described below and were included in this study (Fig. 1).

Appropriate ethical clearance was obtained from the ethical committee of both universities. Written informed consents were obtained from all patients before undergoing any surgical procedures.

A detailed history was obtained from all patients including the cause of their deformity, their present complaint, duration, previous performed operations, associated illnesses and any additional complications.

Clinical examination had been scheduled for all patients regarding evaluation of lacrimal system function, medial canthal position in addition to eyelid measurements.

Clinical examination by Inspection; to detect the visible traumatic deformities, any aesthetic and functional compromises including the shape and degree of movement of the eyelids, epiphora and Epicanthal folds. Palpation of the upper mid facial skeleton to identify and detect any bony abnormalities (overlapped margins, steps, spiky ridges and callus over production). Comparison with the other side or with the aid of radiological findings of bony displacement and callus overproduction.

Visual impairment and eye movements were evaluated by ophthalmological consultation. Irrigation and probing were used for evaluation of the nasolacrimal system. Bowstringing test was used to evaluate detachment of the MCT which can be determined by subcutaneous palpation of MCT as one stretches the lid laterally.

CT scan examination in both axial, coronal and sagittal planes defines the extent of the fractures unilaterally and bilaterally and documents any associated fractures. Patients were photographed (frontal and close up views) preoperatively and at 1 week and at 1, 3 and 6 months postoperatively.

Eyelid measurements included the inter-canthal distance (ICD), the interpupillary distance (IPD) and the palpebral fissure length (PFL).

Telecanthus was assessed by recording the distance (in millimetres) measured between the facial midline and the medial canthus of the injured eye that will be compared to the corresponding values of the uninjured eye preoperatively and at all postoperative follow-up intervals.

The postoperative follow-up examination was scheduled daily during the first week and then weekly during the first month then monthly until the sixth month. Photographs were taken preoperatively and at 1, 3 and 6 months postoperatively.

The functional, aesthetic and numerical results were evaluated for all patients throughout the follow-up periods at 1, 3 and 6 months postoperatively together with radiographic evaluation and the presence of complications.

This technique was applied in 23 post-traumatic telecanthus patients.

Surgical technique

The surgical technique used differed slightly from patient to patient. Essentially, the objective of our surgical technique was to reattach and fix the medial canthal tendon posterior and superior to the posterior lacrimal crest along the medial orbital wall so as to give it an adequate depth. It is advisable to overcorrect for the medial canthal dystopia because postoperative relapse is possible as a result of the extensive pull of the orbicularis muscle.

When canthopexy was performed as an isolated procedure, Surgical exposure was conducted sequentially through a Z-plasty incision that was typically performed for the release of a rotational transpositional myocutaneous triangular flap of the upper eyelid. This was then followed by careful and detailed exposure of all bony boundaries of the medial orbital wall and elimination of any overlap of the margins. Extensive dissection was then performed for exposure of the MCL after freeing all the scar tissues. The lacrimal system was taken care of against any injury in all cases (Figs. 2–5).

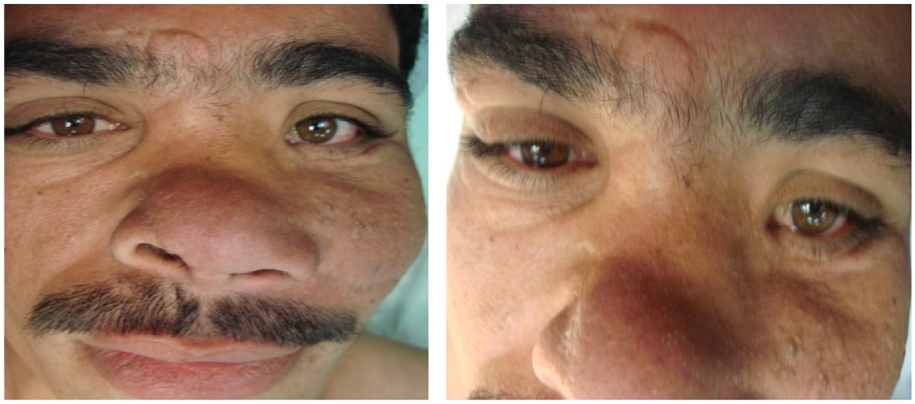

Fig. 1. Frontal photograph showing posttraumatic telecanthus of the left MCT.

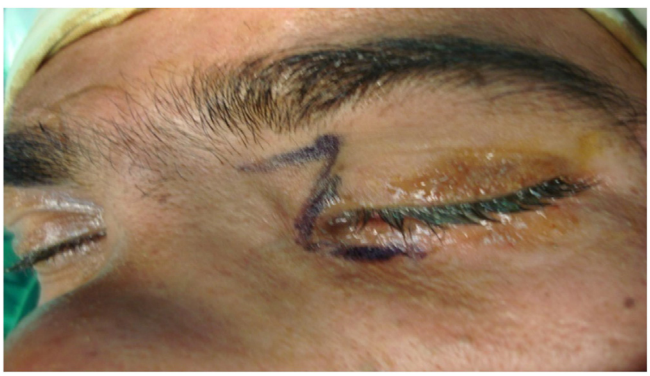

Fig. 2. A photograph showing the triangular rotational transpositional upper eyelid flap.

In order to reconstruct the medial canthal attachment, two implants were fundamentally demanded, one functions to re-capture the MCT while the other aims to permit the establishment a firm and steady point for reduction and fixation. The first implant was a 3/0 Prolene suture mounted to a straight needle which was then used to engage the MCT. The second implant was a mini screw used to secure the Prolene suture with the attached reconstituted medial canthal tissues, so as to achieve a firm bony fixation. If the MCT was damaged as a result of trauma, a firm bite was taken through the medial canthal tissues with the suture.

The second implant used to establish a firm and steady point of reduction and fixation, was either a titanium mini-screw fixed to the frontal or lacrimal bone or a Micro plate (or orbital mesh) securely anchored to the frontal bone after bending and contouring to adapt to the configuration of the medial orbital wall (Fig. 4).

The hole for screw placement is positioned at the postero-superior aspect of the lacrimal bone. If no lacrimal bone is evident as a consequence of bone loss, the nylon suture engaging the MCT was anchored to a self-tapping mini-screw placed through within a rigidly fixed medial orbital wall bone graft (Fig. 6) or the suture is anchored to the stabilizing fixative microplate.

Once it is anchored and firmly stabilized along the medial orbital wall, the 2.0 mini-screw or the 1.6 mm microplate (Jeil Medical Corporation, Guro-gu, Seoul, Korea) will act as a firm counterstone towards which the MCT is anchored and reduced as the Prolene suture is pulled. The microplate must possess satisfactory rigidity and strength to resist deformative forces created as the nylon suture is pulled through it.

Bow-string test was then executed in order to evaluate the intra-operative constancy and steadiness of the reduced medial canthal tendon. Grasping the lateral canthus with the aid of a hook and pulling it laterally with a force sufficient to displace the lateral canthus laterally, the medial canthus was monitored and checked for lateral dislodgement or loss of anchorage.

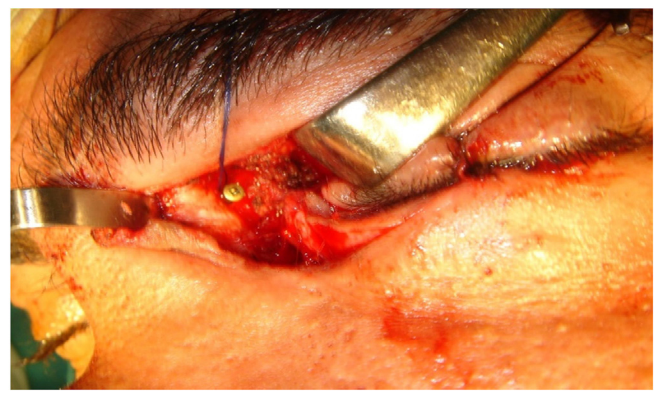

Fig. 3. A photograph showing the mini-screw anchored to the postero-superior aspect of the medial orbital wall.

Fig. 4. A photograph showing transpositioning of the upper eyelid triangular rotational flap inferior to the reattached MCT providing extra-reinforcement and support.

After restoring the anatomical bony continuity and tightening of the medial canthal tendon, the rotational transpositional myocutaneous upper eyelid triangular flap was rotated and sutured into the lower eyelid defect created after postero-superior reduction, elevation and suspension of the MCL so as to provide vertical support and consolidation to the MCL after its reattachment thus correcting the downward slanting of the medial palpebral fissure angle at the same time. The flap was naturally rotated downward to a line consistent with the direction of the lower

Fig. 5. A photograph showing 1-week postoperative view of the surgical site.

eyelid palpebral fold leaving the suture line concealed within the normal eyelid skin crease.

To preserve the normal canthal concavity, the under surface of the flap is sutured to the underlying periosteum. Finally, the wound was then closed in 2 layers using 5\0 polyglactin 910 sutures (Vicryl; Ethicon Inc) for the subcutaneous tissues and 6\0 Prolene interrupted sutures for skin closure.

Postoperative measures

1. The surgical site was dressed with steri-strips which were left in situ for 3–5 days while occlusive eye dressings were applied for one day.
2. All patients were nursed in a semi sitting position.
3. 50–100 mg/kg/day cephalosporin was administered for 3 days post operatively in divided doses intravenously and orally for another two days and continued for longer period as indicated. All patients received local antibiotic-corticosteroids eye drops for seven days.
4. All patients were fit to be discharged on the 3rd post-operative day.
5. Skin stitches were removed after 7 days in the outpatient clinic.
6. The patients were followed up for 6 months post operatively daily for the first week, twice weekly in the second week, once weekly for the next month, and once monthly for six months for evaluation of functional, aesthetic and numerical (biometric) assessment.

Functional assessment was monitored by ophthalmological consultation regarding visual impairment and movements of the eye together with the integrity of the nasolacrimal system that was assessed by the aid of irrigation and probing preoperatively and at 1 week and 1, 3 and 6 months postoperatively. Bow-string test was performed preoperatively as well as postoperatively to assess consolidation of reduction and attachment of the MCT.

Numerical assessment was evaluated by recording medial canthal position through recording the inter-canthal distance (ICD), the interpupillary distance (IPD) and the palpebral fissure length (PFL) preoperatively and at 1, 3 and 6 months postoperatively. Telecanthus was assessed by recording the distance (in millimetres) measured between the facial midline and the medial canthus of the involved eye and compared with the value of the uninvolved eye at different time intervals.

The inter-canthal distance (ICD) or the distance between the right and left medial canthi is about 32 mm in the adult and the telecanthus means increase in this distance more than half of the interpupillary distance. The ICD was measured in mms. by a caliper or polygauge between both medial canthi.

The interpupillary distance (IPD) or the distance between the centre of the two pupils (in normal gaze) is about 60 mm in adults and was measured in mms. by a calliper or polygauge between the centre of both pupils with the eyes in a forward gauze.

The palpebral fissure length (PFL) is the distance between the medial and lateral canthi of the same eye and was measured in mms. by a calliper or polygauge between the medial and lateral canthi of the involved eye and compared with the value of the uninvolved eye.

Approximation of normal can be obtained by recognizing that the intercanthal distance should be equal to the palpebral fissure length (PFL) and the medial canthus should be midway between the midsagittal plane of the nose and the centre of the pupil [19].

Aesthetic assessment was evaluated by patient satisfaction on frontal and close-up photographs preoperatively and at1week and 1, 3 and 6 months postoperatively.

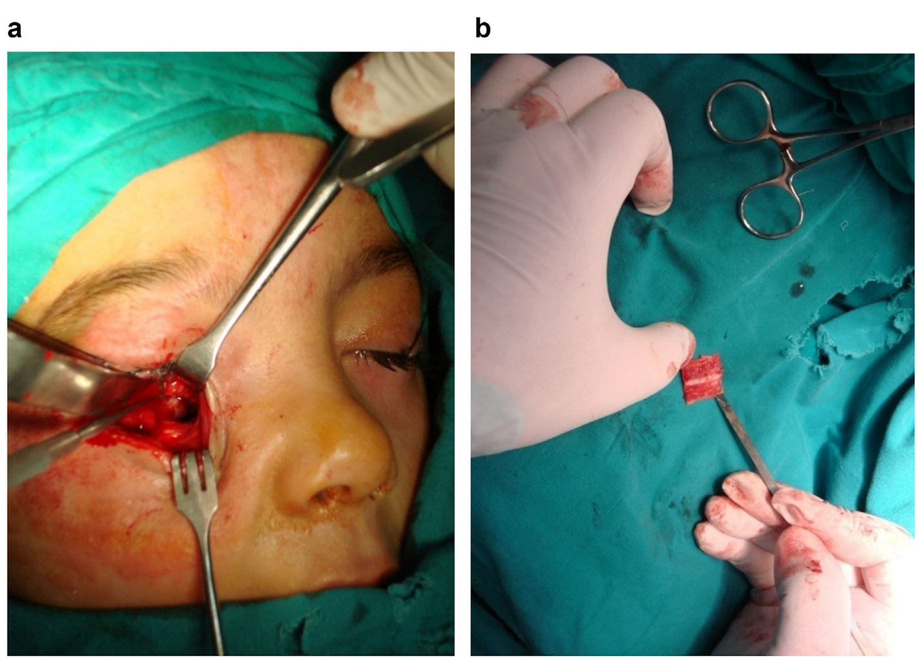

Fig. 6. (a) A photograph showing bony defect of the medial orbital wall. (b) calvarial bone graft for reconstruction of the medial orbital wall.

Radiographic assessment was evaluated by axial, coronal and sagittal C.Ts preoperatively and at 1, 3 and 6 months postoperatively.

Statistical analysis

Normally distributed quantitative data were presented as mean and standard deviation. Repeated measures ANOVA test was used to compare values at different observation times. Tukey's post hoc test was used for pairwise comparison of different observations. Paired *t*-test was used to compare the involved and uninvolved eyes. The significance level was set at $p \leq 0.05$.

Results

A total of twenty-three patients (fourteen males and nine female patients) were treated from posttraumatic telecanthus. The average age of patients at their first presentation was 31.3 years ranging from 16 to 43 years. The aetiology of injury comprised motor vehicle accidents (nine patients), road traffic accidents (seven patients), falling from height (four patients) and direct assault (three patients). The mean duration of injury before patients seek treatment was 1.4 years (ranging from 2 months to 2 years). Average follow-up for all patients was 5 months (ranging from 4 to 6 months).

Common clinical manifestations of patients included [1] Medial canthal, eyebrow or forehead scaring, 2) telecanthus [3], eyelid ptosis, and [4] epiphora.

Medial Canthoplasty with mini screws was performed in 15 patients while a Y-shaped micro plate was utilized in 8 patients.

The average recorded distance from the facial midline to the medial canthus pre and post-operatively was 21.5 and 15.5 respectively.

Clinical evaluation at the postoperative period was uneventful as it showed healing improvement of the surgical sites with no signs of infection as well as highly acceptable aesthetic results in all patients. Post-operative relapse was not recorded in all cases. Also, neither scar contractures, wound webbing nor trapdoor deformities were recorded in any patient because of the v-type configuration of the surgical scar (Fig. 4). However, a small dog-ear defect was noticed in early cases developed at the pivot point of the upper eyelid rotational flap that had spontaneously resolved through-out the follow-up intervals. Wider undermining of the pedicled flap, as well as more precise trimming prevented future dog-ear formation in the succeeding patients.

At the third post-operative day, patients returned to our outpatient clinic for wound examination and to change the surgical dressing to last for another 2 days. stitch removal was performed one week later.

Patients were re-evaluated at 1,3 and 6 months postoperatively and showed absence of any evidence of recurrence with concealed surgical wounds yielding satisfactory aesthetic outcomes and demonstrating achievement of medial canthal concavity (Fig. 7). Neither ectropion nor eyelid distortion was evident and a fully functional lacrimal system was attained.

Aesthetical assessment

All patients were satisfied except one that was overcorrected and reoperated for re-correction. Another one was under corrected and had undergone revision. Wound dehiscence occurred in one patient 6 weeks post-operatively, resulting in loss of medial canthal anchorage and accordingly was re-operated and treated.

Functional assessment

Ophthalmologic consultation revealed normal ocular motility and visual acuity in all patients with fully functional lacrimal systems. All 23 patients had resolution of epiphora (tearing). Five patients had 1.5–2 mm of ptosis; however, they refused to be re-operated as they were pleased with the attained results.

In all patients (except for the one of wound dehiscence), the postcanthopexy Bow String test yielded negative results as it failed to cause detachment or lateral displacement of the medial canthus throughout all the follow-up intervals.

Numerical assessment

Numerical assessment was evaluated by recording medial canthal position through recording the inter-canthal distance (ICD), the interpupillary distance (IPD) and the palpebral fissure length (PFL) preoperatively and at 1, 3 and 6 months postoperatively (Table 1). Telecanthus was assessed by recording the distance (in millimetres) between the facial midline and the medial canthus of the injured eye compared to the uninjured eye.

Pre-injury ICD, IPD and PFL values were measured in mm using a polygauge at the palpebral angles, canthi and nasal midline and compared to postcanthopexy dimensions.

The postoperative medial canthal position was considered satisfactory in all patients (Figs. 8 and 9), showing a considerable improvement compared with the preoperative position.

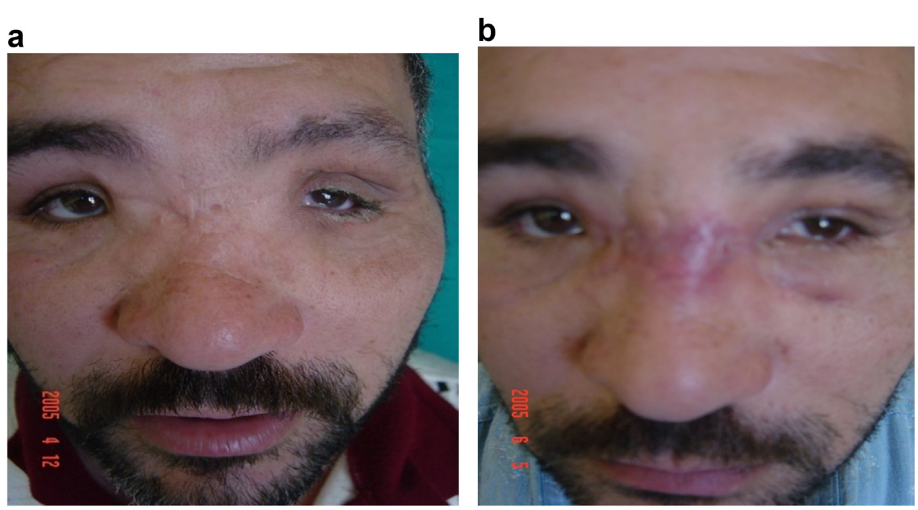

Fig. 7. 7a: Preoperative photograph. 7b: Postoperative photograph.

Table 1
Mean of values of different measured parameters at different follow-up intervals.

Patient # 1	ICD	IPD	PFL of involved eye	PFL of uninvolved eye	Midline to M canthal distance of involved eye	Midline to M canthal distance of uninvolved eye
Preop	38	69.4	12.1	15.7	21.5	16.3
1 month	34	63.3	14.5	15.7	16.5	16.3
3 month	33.5	62.7	15	15.7	15.5	16.3
6 month	33	62.4	15	15.7	15.5	16.3

Statistical results

Inter-canthal distance (ICD): The highest mean value was recorded pre-operatively (38 ± 6.5), then gradually decreased by time to reach its lowest mean at 6 months (33 ± 5.2). ANOVA test revealed a significant difference between the pre-operative value and the different post-operative observations ($p = 0.02$). (Table 2, Fig. 10),

Inter-Pupillary distance (IPD): The highest mean value was recorded pre-operatively (69.4 ± 10.76), then gradually decreased by time to reach its lowest mean at 6 months postoperatively (62.4 ± 10.9). ANOVA test revealed no significant difference between the pre-operative value and the different post-operative observations ($p = 0.089$). (Table 2, Fig. 11),

Palpebral fissure length (PFL): The lowest mean value was recorded pre-operatively (12.1 ± 3), then gradually increased by time to reach its highest mean at 3 months post-operatively, and remained constant at 6 months post-operatively (15 ± 2.6).

ANOVA test revealed a significant difference between the pre-operative value and the different post-operative observations ($p = 0.0007$).

Comparing the involved and non-involved eyes, significantly higher mean value was recorded in the uninvolved eye pre-operatively ($p = 0.0003$). Post-operatively at 1, 3 and 6 months, the difference between both eyes was not statistically significant ($p = 0.157$, $p = 0.42$ respectively). (Table 3, Fig. 12),

Midline to M canthal distance: The highest mean value was recorded pre-operatively (21.5 ± 4.1), then gradually decreased by time to reach its lowest mean at 3 months post-operatively, and remained constant at 6 months post-operatively (15.5 ± 2.8).

ANOVA test revealed a significant difference between the pre-operative value and the different post-operative observations ($p = 0.000$). Comparing the involved and non-involved eyes, significantly lower mean value was recorded in the uninvolved eye pre-operatively ($p = 0.000$).

Post-operatively at 1, 3 and 6 months, the difference between both eyes was not statistically significant ($p = 0.86$, $p = 0.429$ respectively). (Table 4, Fig. 13),

Radiographic assessment

None of the post-canthopexy CT scans showed microplate deformation or mini-screw loosening, dislodgement or any other encountered mechanical failures (Figs. 14 and 15).

Discussion

The medial canthal tendon (MCT) is an important structure that supports the medial canthus, provides proper apposition of the eyelids against the eye globes, as well as promoting a functioning lacrimal apparatus [31].

The normal medial canthus has two major anterior and posterior limbs and a minor superior limb [7–9,31–37]. The predominant anterior limb possesses a vast and distinct attachment to the anterior lacrimal crest and the frontal process of the maxillary bone whereas the posterior limb, which is the most relevant to this technique and had not been recognized until 1970, confirms along the posterior lacrimal crest and the medial orbital wall [31].

In any successful medial canthopexy, the counterstone of success is to reconstruct and re-attach the MCT along the medial orbital wall as medially and posteriorly as possible [21]. The fact that implies just reducing and pulling the right and left canthi against each another will lessen the telecanthus but will not permit adequate apposition of the eyelids against the eye globe. Accordingly, an extra and supplementary posterior vector of reduction would be essential to sustain adequate repositioning of the lids against the curved configuration of the eyeball.

Telecanthus or widening of the intercanthal distance, is the leading, distinct and readily obvious clinical sign of medial canthal tendon avulsion or derangement. Telecanthus requires detachment and avulsion

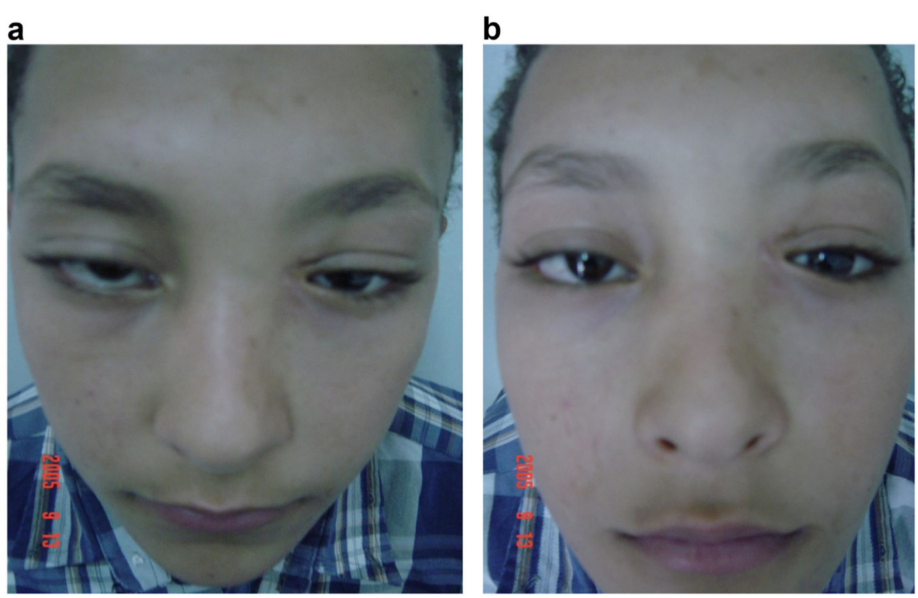

Fig. 8. 8a: Preoperative photograph. 8b: Postoperative photograph.

Fig. 9. 9a: Preoperative photograph showing scaring of the medial canthal area with widening and downward slanting of the medial palpebral fissure angle. 9b: Postcanthopexy photograph.

Table 2
Comparison of mean values of ICD and IPD at different follow-up intervals (ANOVA test).

Time	Inter-canthal distance (ICD)	Inter-pupillary distance (IPD)
Pre-operative	$38^{a} \pm 6.5$	69.4 ± 10.76
1 month	$34^{b} \pm 5.8$	63.3 ± 11.4
3 months	$33.5^{b} \pm 6.1$	62.7 ± 8.5
6 months	$33^{b} \pm 5.2$	62.4 ± 10.9
F	3.43	2.23
P (Effect of time)	0.02*	0.089ns

Significance level $p \leq 0.05$, * significant, ns = non-significant.
Tukey's post hoc test: within the same comparison, means sharing the same superscript letter are not significantly different.

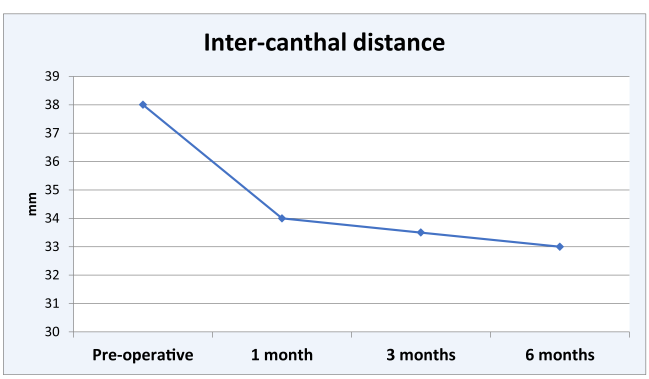

Fig. 10. Line chart showing mean value of inter-canthal distance.

of the posterior limb from its attachment along the posterior lacrimal crest. Normally, the intercanthal distance equals the palpebral fissure length [1].

Medial canthal degloving injuries definitively terminates in mostly common clinical findings of vertically oriented medial canthal lacerations, downward slanting of the medial palpebral fissure, telecanthus, eyelid ptosis, and lacrimal system disfunction [1].

Other readily evident findings of medial canthal ligament avulsion [36,38–42] are roundation of the medial canthal angle, shortening of the palpebral fissural length, epicanthal fold development, eradication or displacement of the caruncle.

Post-traumatic Epiphora frequently results secondary to edema in the immediate posttraumatic period and is not usually considered as an actual realistic sign of injury to the nasolacrimal drainage system. The integrity of the lacrimal system should always be evaluated through irrigation and probing. Continuous tearing of patients despite intact lacrimal system may be attributed to distraction of the puncta away from the tear lake as a sequalae of anterior displacement of the medial canthus [38].

Regarding post-traumatic ptosis, laceration or avulsion of the levator palpebrae superioris muscle, paresis of the Occulomotor nerve, ocular muscles hematoma, and lateral displacement of the tarsal plate all are considered possible etiological causes [38,39,41,42].

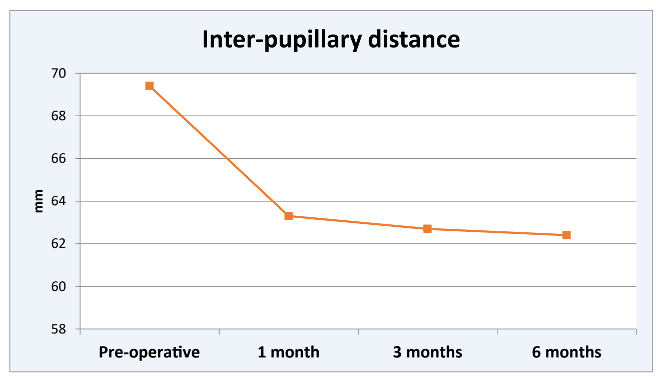

Fig. 11. Line chart showing mean value of inter-pupillary distance.

Table 3
Comparison of mean values of palpebral fissure length at different follow-up intervals (ANOVA test) and significance of difference between involved and uninvolved eyes.

Time	The palpebral fissure length of involved eye	PFL of uninvolved eye	t	P (between both eyes)
Pre-operative	$12.1^{b} \pm 3$	15.7 ± 3.2	3.94	0.0003*
1 month	$14.5^{a} \pm 2.4$	15.7 ± 3.2	1.44	0.157ns
3 months	$15^{a} \pm 2.6$	15.7 ± 3.2	0.81	0.42ns
6 months	$15^{a} \pm 2.6$	15.7 ± 3.2	0.81	0.42ns
F	6.26	0		
P (Effect of time)	0.0007*	1ns		

Significance level $p \leq 0.05$, * significant, ns = non-significant.
Tukey's post hoc test: within the same comparison, means sharing the same superscript letter are not significantly different.

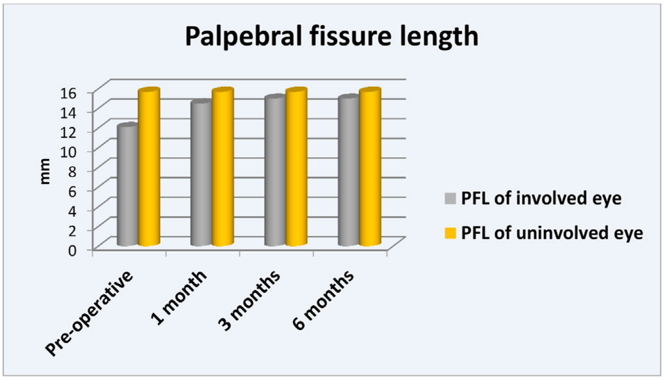

Fig. 12. Bar chart showing mean value of palpebral fissure length in involved and uninvolved eye.

Table 4
Comparison of mean values of midline to M canthal distance at different follow-up intervals (ANOVA test) and significance of difference between involved and uninvolved eyes.

Time	Midline to M canthal distance of involved eye	Midline to M canthal distance of uninvolved eye	t	P (between both eyes)
Pre-operative	$21.5^{a}\pm4.1$	16.3 ± 3.9	4.41	0.00*
1 month	$16.5^{b}\pm3.7$	16.3 ± 3.9	0.18	0.86ns
3 months	$15.5^{b}\pm2.8$	16.3 ± 3.9	0.799	0.429ns
6 months	$15.5^{b}\pm2.8$	16.3 ± 3.9	0.799	0.429ns
F	16.44	0		
P (Effect of time)	0.000*	1ns		

Significance level $p \leq 0.05$, * significant, ns = non-significant.
Tukey's post hoc test: within the same comparison, means sharing the same superscript letter are not significantly different.

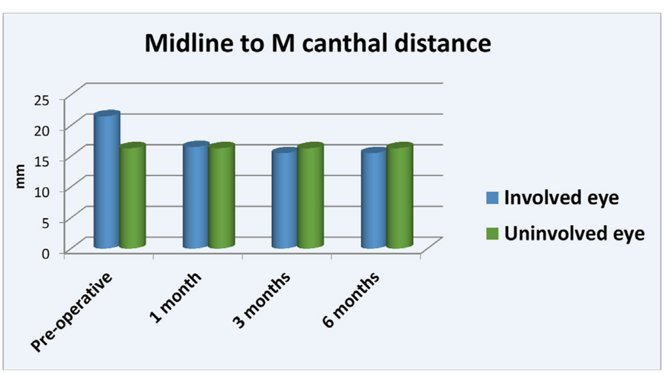

Fig. 13. Bar chart showing mean value of midline to M canthal distance in involved and uninvolved eye.

In our study, we revealed a high incidence of levator palpebrae superioris muscle injury among our patients resulting in upper eyelid ptosis secondary to reduced levator function. We hypothesize that this is mostly related to the severity of dislocation of the degloved tissues of the MCT from its origin. The findings of our study revealed a noticeable improvement of ptosis secondary to re-establishment of MCT attachment.

For the purpose of correction of post-traumatic Telecanthus, several surgical techniques had been advocated for reconstruction of the disrupted and dislodged medial canthal tendon. Options included unilateral wire fixation, transnasal wiring, intranasal wiring, bone-screw fixation with the Mitek mini bone anchor system [43] and microplate fixation [36,39,40,44–48].

Transnasal wiring has been considered by many surgeons to be the most widely used methods to perform medial canthopexy [17,21].

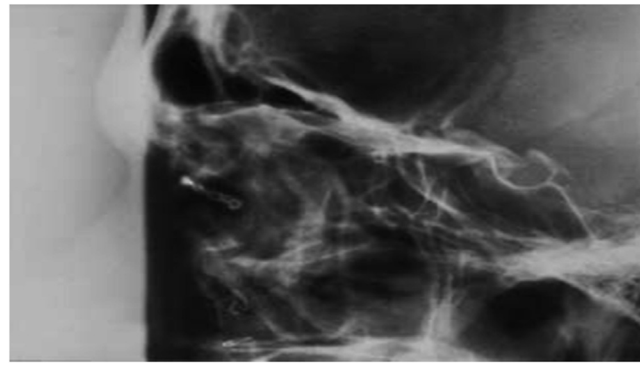

Fig. 14. Sagittal C.T showing microplate fixation of the MCL.

Fig. 15. Occipitomental view showing mini-screw fixation of the MCL.

However, other surgeons postulated that it is a technically difficult and technique sensitive procedure that may endanger and damage the contralateral orbital structures [17]. It also requires an incision on the contralateral side with a resultant visible scar, to which some patients may refuse and reject. However, Transnasal wiring had been subjected to many complications related to the use of metallic wires which had been reported to occur in the form of wire loosening, fatigue fracture, skin irritation, and device exposure or extrusion [17]. In our cases, we performed unilateral mini-screw or microplate fixation on the affected side avoiding any incisions or noticeable cutaneous scars on the unaffected side. The complication of screw or plate loosening and extrusion had not been reported in any of our cases though the 6 months follow-up period.

It has been postulated that with any Canthopexy, the counterstone to effective reconstruction of the medial canthal tendon is appropriate achievement of postero-superior reduction and reattachment of the MCT in order to reduce the intercanthal distance, re-establish the normal anatomical relationships of the eyelids and palpebral fissures, and restore the normal apposition of the eyelids against the globe.

Ideally, the medial canthal posterior limb must be secured firmly to bone because of the thin periosteum surrounding the posterior lacrimal crest [44]. Again, reattachment of the medial canthal tendon after avulsion should be oriented posterior as well as superior to the posterior lacrimal crest [7,43].

However, the MCT have been reattached by many authors at different sites on the medial orbital wall, including the anterior lacrimal crest, superior to the anterior lacrimal crest [17], and the posterior lacrimal crest [49].

The fact that the medial canthus does not shift in position after the anterior limb of the MCT is divided in dacryocystorhinostomy also supports and encourages this hypothesis [31,35,36]. This evidence leads most techniques of medial canthopexy advocating the fixation of the MCT to the posterior lacrimal crest or deeper, in order to avoid canthal malposition after surgery [50–53].

The legality of our technique depends upon the fact that the ultimate strength and bulk of the posterior limb of the MCT despite the anterior limb can ensure a secure, stable and permanent reduction of the medial canthal tendon.

In all cases of our study, we used the bone of the posterior superior lacrimal crest to provide a secure stable point of fixation because we believe that this point provides the desired normal depth and adequate support to the reduced medial canthal tendon.

The low resistance of the palpebral tissues to the retractable forces of postoperative scarring can predispose patients to undesirable surgical outcomes [54]. Therefore, we planned a transpositional rotational myocutaneous flap transpositioned from the upper to the lower eyelid targeting to elevate and support the fixed, reduced MCT by performing a Z-shaped incision thus achieving proper position and correcting the downwards slanting of the medial canthus in cases of degloving injuries.

Despite various surgical techniques advocated, medial canthopexy still represents a challenge to many surgeons and considered by many as a difficult procedure depending on the incident of that the low resistance of the palpebral tissues to the retractable forces of postoperative scarring can predispose patients to undesirable surgical outcomes. Accordingly, postoperative complications related to scar contraction, exaggerated pull on the wires, and infection had subjected many surgeries various postoperative shortcomings and drawbacks [17].

Local flaps in the form of transpositional, rotational and advancement flap designs had been considered for reconstruction of MCT degloving injuries as they provide superior cosmetic outcomes associated with a low complication rate [55–65]. The choice of flap design is greatly dependent on local tissue anatomy, surgical wound configuration as well as the surgeons experience.

After considering all flap-design parameters, the authors adopted to describe a rotational transpositional myocutaneous upper eyelid flap to reconstruct the presented medial canthal deformity aimed to correct the post-traumatic Telecanthus. The rotational transpositional flap offers several advantages as it provides a good match of local tissue thickness and colour, conceals postoperative scars by placing them in normal facial folds and contour lines minimizing the risk of their visibility, yields minimal complications as ectropion, and achieves normal medial canthal concavity by permitting anchorage of the pedicle flap deeply into the fibrous tissues [65].

There are several advantages of the authors' adopted technique, first; tension-free reconstruction of the medial canthal defect, second; avoiding the formation of disfiguring scar contractures, webbing or trapdoor deformity, third; the technique, avoids the use of transnasal awls and/or drills and does not require dissection within the contralateral orbit as it can be performed unilaterally, fourth; in cases of comminution of the nasal bone or the medial orbital wall, our technique can be performed after considering grafting of the medial orbital wall, fifth; less traumatic placement of anchoring apparatus in bone as a consequence of using the self-drilling mini-screws or the malleability of the microplates, sixth; it can be used in cases with deficient bone after grafting of the medial orbital wall where the microplate can be used simultaneously for fixation of the graft and providing anchorage for the suspensory Prolene suture and seventh; the z-plasty incisions are consistent with the direction of orbicularis muscle contraction, thus providing natural appearing medial canthal angle as well as tension-free closure of the defect avoiding a resultant unsighty visible scar.

The results of our study greatly match those of Jelks et al. [56] in 2002 who utilized a medially based upper eyelid myocutaneous flap to reconstruct medial canthal defects following tumour resection and reported satisfactory aesthetic results.

Yildirim et al. [62] in 2001 reported the use of combined V–Y advancement nasolabial and glabellar flaps, which yielded results similar to our technique. In our study, the upper eyelid myocutaneous triangular flap provided not only plenty of tissues that easily facilitated the reconstruction of the natural concavity of the medial canthal area but also permitted the creation of an inconspicuous donor scar, positioned within the natural anatomical crease of the eyelid.

On the other hand, Chao et al. [58] in 2010 have reported the use of a glabellar and a V–Y advancement myocutaneous flap of the orbicularis oculi muscle for the reconstruction of medial canthal defects. However, the main reported limitations of this method are the additional visible scars that not only violate natural skin crease lines, but also their contracture that leads to trap door deformity and webbing and subsequently poor cosmetic results.

However, our results give a great support and greatly match those of Lykoudis et al. [57] in 2015 who used a double flap technique in the form of a glabellar and a nasolabial flap designed and raised on either side of the medial canthal defect to treat 17 patients and postulated that because of the ample tissue provided and the w-plasty outline of the resulting surgical scar neither disfiguring scar contractures nor trapdoor deformities were noticed. Subsequently, all patients were satisfied with the resultant aesthetic outcome.

Regarding the results of our study, the postoperative medial canthal position (as recorded from the midline to the M. canthus and compared with the uninvolved eye) was considered satisfactory and statistically significant in all patients, presenting a considerable improvement with respect to the preoperative position with nearly total correction of their posttraumatic Telecanthus. The ICD, IPD and PFL values achieved statistically significant dimensions in all postcanthopexy records.

The ICD showed its highest mean value as was recorded pre-operatively (38 ± 6.5), then gradually decreased by time to reach its lowest mean at 6 months (33 ± 5.2), while the IPD showed its highest mean value as was recorded pre-operatively (69.4 ± 10.76), then gradually decreased by time to reach its lowest mean at 6 months post-operatively. The PFL of the involved eye showed its lowest mean value as was recorded pre-operatively (12.1 ± 3), then gradually increased by time to reach its highest mean at 3 months post-operatively, and remained constant at 6 months post-operatively (15 ± 2.6).

This can be attributed to the successful and maintained reattachment of the MCT at a postero-superior position establishing near normal eyeball and lid dimensions and relations.

Moreover, the Medial canthus to midline distance of the involved eye showed its highest mean value as was recorded pre-operatively (21.5 ± 4.1), then gradually decreased by time to reach its lowest mean at 3 months post-operatively, and remained constant at 6 months post-operatively (15.5 ± 2.8).

ANOVA test revealed a significant difference between the pre-operative value and the different post-operative observations ($p = 0.000$). Comparing the involved and non-involved eyes, significantly lower mean value was recorded in the uninvolved eye pre-operatively ($p = 0.000$).

Post-operatively at 1, 3 and 6 months, the difference between both eyes was not statistically significant ($p = 0.86$, $p = 0.429$ respectively), These findings denote correction of telecanthus as related to the involved eye.

Postoperative Ophthalmologic consultation revealed normal ocular motility and visual acuity in all 23 patients with fully functional lacrimal systems where all patients had resolution of epiphora (tearing). However, five patients had 1.5–2 mm of post-operative ptosis; however, they refused to perform corrective surgery as they were satisfied and convinced with their comprehensive results.

In all cases of the present study, the mini-screw was eventually placed posterior and superior to the lacrimal fossa. Despite this position resulted in distortion of the upper canaliculus in 7 patients, lacrimal drainage had demonstrated adequate function in all patients owing to the fact that the lower canaliculus responsible for the majority of lacrimal function remained uncorrupted or deformed [66–68].

In all patients (except for the one of wound dehiscence), the post-canthopexy Bow String test yielded negative results as it failed to cause detachment or lateral dislodgement of the medial canthus throughout all the follow-up intervals. In this case, wound dehiscence can be attributed to the excessive stress developed along the MCT-bone anchorage site and the skin with resultant medial canthal detachment and eventually total wound dehiscence.

The results of our study were in accordance with those of Howard et al. [16] in 1992 who performed medial canthopexy by using micro-plates and shore et al. [21] using miniplates and had attained successful results regarding medial canthal position.

The results achieved in our study correlates with those of Sharma et al. [69] in 2006 who performed Medial canthopexy in 5 patients using biodegradable screws and yielded comparable results.

The findings in our study perfectly matches with those of Engelstad et al. [10] in 2012 who treated bilaterally created medial canthal degloving injuries in 5 cadavers with canthopexy by using miniplates and transcaruncular barb. They assessed medial canthal positions by recording ICD and palpebral aperature width (PAW) and compared preinjury with postcanthopexy dimensions and postulated significant successful MCT reduction and position.

The present study gives a great support to the study performed by Chahal et al. [70] in 2016 who treated 18 patients with a combined glabellar and lateral rotational flap for reconstruction of deep medial canthal defects superimposed medial canthal tendon detachment. Although their study lacked objective outcome measures, yet it demonstrates excellent cosmetic results with minimal visible scars.

As a consequence of severe NOE assaults and degloving injuries, the resultant presenting medial orbital wall bone fragment is not sturdy enough to allow stable anchorage for plate and screw fixation [71]. A robust miniplate or orbital mesh, that can be readily adapted by the surgeon, provides the required stable point for medial canthal reduction and fixation. Although medial canthopexy can be executed in the absence of medial orbit wall bone, the MCT must be dissected out, engaged and ultimately attached to some kind of stable tissue in order to restore the intercanthal distance, normal palpebral angulation and palpebral fissural length and ultimately avoid postoperative relapse. Accordingly, the authors recommend consideration of bone grafting in this area when necessary.

Conclusions

1. Medial Canthopexy using mini-screws and/or microplates is a simple, easy and reliable technique for surgical correction of posttraumatic MCT detachment with resultant Telecanthus.
2. We believe that this technique gives acceptable aesthetic and functional results because the myocutaneous flap originates in the peri-orbital region representing an ideal option as there is no colour or contour mismatch, and incisions will heal with minimally visible scars.
3. The myocutaneous rotational transpositional flap should be anchored deeply to the fibrous tissue to recreate the concavity of this specific area.
4. The simplest and most effective treatment is always a big key to the success of a surgeon.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.adoms.2021.100051.

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