Influence of kinesiologic tape on postoperative swelling, pain and trismus after zygomatico-orbital fractures

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Abstract

Surgical treatment of zygomatico-orbital (ZO) fractures is a common procedure in maxillofacial surgery. Often accompanied by pain, trismus and swelling, postoperative morbidity is a major disadvantage, affecting patients’ quality of life. The application of kinesiologic tape (KT) improves the blood and lymph flow, removing congestions of lymphatic fluid and haemorrhages. The aim of this study was to find out if the application of kinesiologic tape prevents or improves swelling, pain and trismus after zygomatico-orbital fracture surgery, improving patients’ postoperative quality of life.

A total of 30 patients were assigned for treatment of zygomatico-orbital fractures and were randomly divided into treatment either with or without kinesiologic tape. Tape was applied directly after surgery and maintained for at least 5 days postoperatively. Facial swelling was quantified using a five-line measurement at six specific time points. Pain and degree of mouth opening was measured. Patient’s subjective feeling and satisfaction was queried.

The results of this study show that application of kinesiologic tape after zygomatico-orbital surgery significantly reduced the incidence of swelling with an earlier swelling maximum, and decreased the maximum turgidity for more than 60% during the first 2 days after surgery. Although, kinesiologic tape has no significant influence on pain control and trismus, mouth opening increased earlier after operation in the kinesiologic tape group compared to the no-kinesiologic tape group. Furthermore, patients with kinesiologic tape felt significantly lower morbidity than those without kinesiologic tape. Therefore kinesiologic tape is a promising, simple, less traumatic, economical approach, which is free from adverse reaction and improves patients’ quality of life.

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1. Introduction

Midface fractures involving zygomatico-orbital (ZO) fractures are common in maxillofacial surgery (Rogers et al., 2000, Erdmann et al., 2008, van den Bergh et al., 2012, Gassner et al., 2003, Naveen Shankar et al., 2012). Often attended by pain, trismus and swelling, postoperative morbidity is a major disadvantage, affecting patients’ quality of life (Miloro, 2004, Trivellato et al., 2011, Folkestad et al., 2006). Tissue reactions are thought to arise from the inflammatory response as a direct and immediate consequence of the surgical procedure (Samad et al., 2001). Complications as haemorrhage emphysema or sepsis may occur (Trivellato et al., 2011). The adverse effects of ZO surgery on life quality have been reported to be increased in patients who experience swelling, pain and trismus. It seems appropriate to study the causes and the effects of ZO fractures managed by open reduction and rigid internal fixation at the present time, when economic factors are included in assessment of the...
treatment. The break in social and professional activity of injured individuals and the scale of the problem indicates the necessity to reduce or eliminate these side effects, thus, improving patients' satisfaction after treatment of ZO surgery (Calderoni et al., 2011).

Several methods to control the immediate inflammatory response associated with head and neck surgery have been described and used, including the use of drugs such as analgesics (Kim et al., 2009, Aznar-Arasa et al., 2012; de Sousa Santos et al., 2012), corticosteroids (Markiewicz et al., 2008; Thoren et al., 2009), antibiotics (Kneip and Loukota, 2010; Andreasen et al., 2006) and proteolytic enzymes (Al-Khateeb and Nusair, 2008), laser application (Markovic and Todorovic, 2007, Roynesdal et al., 1993) or physical therapeutic methods like cryotherapy (Rana et al., 2012) or manual lymph drainage (MLD) (Szolnoky et al., 2007). No single modality of management significantly prevents and/or significantly reduces the occurrence of swelling, pain and trismus without potential undesirable side effects. Therefore further techniques for a better pain, swelling and trismus control should be developed for patients who undergo ZO surgery.

After its introduction in the 1970s, kinesiologic tape (KT) has increasingly become popular in the treatment of sport injuries and a variety of other conditions. There are several claims to the effects of KT including supporting injured muscles and joints, relieving pain, and increasing blood and lymph flow in the injured area. However, there is still little evidence to support these claims and much more research is necessary (Williams et al., 2012; Morris et al., 2012). The use of KT in the management of lymphoedema is gaining popularity. The tape is similar in weight to the epidermis, and lifting the skin, KT improves the blood and lymph flow, removing congestions of lymphatic fluid or haemorrhages (Chou et al., 2012). By providing space, fluids are encouraged to move from areas of higher pressure towards the area of lower pressure, guided by the tape to the desired direction of drainage (Kase et al., 2003). Using this technique may be beneficial for postoperative treatment after head and neck surgery, accelerating drainage of tissue reaction or haemorrhages.

The goal of this study was to find out if the application of KT prevents or improves swelling, pain and trismus after ZO surgery, improving patients' postoperative quality of life.

2. Material and methods

2.1. Patients

Over a period of 12 months, 30 consecutive patients were recruited and prospectively included in our monocentric, parallel-group, open label, randomized clinical trial. 14 female and 16 male patients were enrolled (mean age and standard deviation, 41.4 ± 18.5 years; age range, 18–74 years). Based on the CONSORT 2010 checklist for randomized, controlled, clinical trials (Cochrane Collaboration, Manchester, UK) participants were randomized into two study groups: (i) KT group; (ii) no-KT group. Blinding and placebo control were not possible due to the nature of the KT. Inclusion criteria were: zygomatico-orbital fracture, zygomatico-orbital fractures, Journal of Cranio-Maxillo-Facial Surgery (2013), http://dx.doi.org/10.1016/j.jcms.2013.05.043

2.2. Operation

All operations were performed by two board-certified and specialized Oral and Maxillofacial Surgeons (BHM, CP) under general anaesthesia using nasal intubation. Surgery was performed in sterile conditions following a standardized operation protocol and using standardized approaches from the upper eyelid (blepharoplasty approach), transconjunctival and transoral (if necessary). The reduction of the zygoma was performed by transbuccal hook retraction. Internal fixation was achieved using miniplates (matrix midface plating system, Synthes®, Switzerland). The orbital floor was reconstructed using flexible and resorbable Ethisorb patches (Ethicon, Norderstedt, Germany). Mean operation duration varied from 45 to 60 min.

A single dose of antibiotics (Ampicillin/Sulbactam Kabi 2000 mg/1000 mg) was given preoperatively. All patients stayed in hospital for at least 72 h after surgery. Patients received routine postoperative instructions: Ice pack application for 6 h after surgery, alternating 30 min of application with 30 min of no application. All patients received the same postoperative analgesic drug therapy of 1000 mg Paracetamol (Perfalgan®) intravenously 2 times per day for 3 days; and 600 mg Ibuprofen (Ibu-Ratiopharm®) orally (1st day: Ibuprofen 600 mg 3 times per day, 2nd day: Ibuprofen 600 mg 2 times per day, 3rd day: Ibuprofen 600 mg 1 time per day, 4th day: Ibuprofen 600 mg 1 time per day). There were no postoperative complications.

2.3. Taping

All taping procedures were performed by the same investigator (OR) a certified K-Taping therapist. Skin was cleaned and freed of moist and oils prior to application; if necessary the area was shaved. All tape applications were performed using skin coloured K-Active Tape Classic®, 50 mm × 5 m (K-Active Europe GmbH®, Wiesthal, Germany). Tape length was individually measured for every patient starting at the clavicle to the point of highest swelling. The tape was cut into three equal stripes (approximal 1.5 cm wide). Tape endings were rounded down. The tape was carefully removed from paper backing, trying to touch the adhesive as little as possible. The base was placed slightly above the lymph node area to which the drainage is being directed (supraclavicular nodes). The patient was moved into a stretch position. Tails were placed on to the skin with slight tension (20%). Placement of the lymphatic stripes was directed at the appropriate lymphatic duct crossing the cervical, sub mental, mandibular, submandibular, preauricular and parotid nodes, crossing the zygomatic arch, reaching the infraorbital rim and frontozygomatic suture surrounding the lower eye (Fig. 1). After application the tape was lightly rubbed to activate the medical grade acrylic adhesive. The tape was left for at least 5 days. Edges were trimmed if tape lifted before removal.

2.4. Measurements

All measurements were performed by one of the investigators (OR) at six specific time points (T): Pre-operative (T-1), Baseline (BL) = directly after operation (T0), first (T1), second (T2), third (T3) and seventh (T4) postoperative day.

2.4.1. Swelling

Swelling was assessed with a five-line measurement using a standard plastic tape measure (accuracy ±0.5 mm) placed in contact with the skin: (Line a) most posterior point tragus – most lateral point lip commissure; (Line b) most posterior point tragus – pogonion; (Line c) most posterior point tragus – lateral canthus of the eye; (Line d) lateral canthus of the eye – most inferior point angle of the mandible; (Line e) most inferior point angle of the mandible – middle of the nasal bone (Fig. 2). Marking endpoints for subsequent tape measurements were drawn, using a fine waterproof felt tip pen.
2.4.2. Pain

Pain scores were assessed using a 10 level visual analogue scale (VAS) of 100 mm, representing all pain sensations from none to maximum; where 0 indicates no pain, 5 moderate pain and 10 worst pain possible. Patients were asked to place a mark along the line that corresponded to the amount of pain they were experiencing.

2.4.3. Trismus

Maximal mouth opening was recorded measuring the maximum inter-incisal distance using callipers (Fig. 3).

2.4.4. Subjective feelings

All patients of the KT and the no-KT group were asked to decide how they evaluated their satisfaction and convenience: very satisfied = 1; satisfied = 2; not satisfied = 3. Furthermore, all patients of the KT group were asked to decide whether they find the tape: not disturbing = 1, slightly disturbing = 2, very disturbing = 3; whether the tape is not = 1, slightly = 2, highly = 3 affecting them in their movements.

2.5. Statistical analysis

All statistical analysis were performed using IBM SPSS Statistics software (Version 20.0). In addition to the descriptive statistics, the study groups were compared with each other using the independent samples t-test for differences in means. The significance level was set at 5%. Primary endpoint of the study was increase of swelling between T0 and T0 + X. All other statistical tests were secondary endpoints of the study and were performed in an exploratory manner. The 95% confidence intervals (CI) for mean swelling and VAS measurements were also calculated and displayed in plots. Disturbance, movement and satisfaction were summarized by time with percent patients in each category.

3. Results

3.1. Swelling

All swelling measurements were expressed as mean sum of all five-line measurements (Line a through Line e) for all patients (in cm) at the six specific measurement times (Fig. 4).

Mean sum of all five-line measurements for all patients showed no statistically significant difference pre-operatively (T-1) and
The extent of maximal swelling in the no-KT group was larger and the mean sum of all increases between T0 through T2 and T0 through T3 were highly significant (p < 0.001) comparing the KT and the no-KT group.

Comparing the increase of swelling between baseline (T0) and T1, T2, T3 after operation highly significant differences (p < 0.001) between the KT and the no-KT group were seen (Table 1). Comparing the KT and the no-KT group the different increases of swelling between T0 and T2 and T0 and T3 were highly significant (p < 0.001). While patients in the no-KT group showed an increase in swelling on day two after surgery with mean sum of measurements of 2.2 cm ± 1.6, those in the KT group had reduced swelling with a mean of −1.9 cm ± 3.1. The increase in swelling between T0 and T1 showed no statistical significance (p > 0.05).

Maximal swelling was defined as the difference between the maximal mean sum of all five-line measurements for all patients and the mean sum of all five-line measurements at baseline (T0). The extent of maximal swelling in the no-KT group was larger (2.7 cm ± 1.3) than in the KT group (1.1 cm ± 1.7). This difference was statistically significant (p = 0.007). Patients in the KT group experienced their maximal swelling very early (mean day 0.5, median day 0 (Tmax)) while patients in the no-KT group had maximum swelling on average on day two. This difference was highly statistically significant (p < 0.001).

For the reduction of swelling the pure differences of the mean sum of all five-line measurements for all patients between Tmax and one day after Tmax (Tmax + 1) are displayed in Table 2. Since patients in the KT group did not swell as much as patients in the no-KT group, their reduction is not significantly larger than in the no-KT group (p > 0.05).

Comparing the results for the mean sum of all five-line measurements for all patients one day after the maximal swelling (Tmax + 1) with the initial swelling at baseline (T0), patients in the KT group had a swelling reduction which was −1.1 cm ± 2.2 below initial swelling after operation (T0). The extent of swelling one day after the maximal swelling in the no-KT group still exceeded the initial swelling of T0 by 1.0 cm ± 1.4. This difference in swelling reduction was statistically significant (p = 0.005).

### Table 2

<table>
<thead>
<tr>
<th>Measurement Time</th>
<th>KT group</th>
<th>no-KT group</th>
<th>p-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean swelling (cm)</td>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>T0–Tmax</td>
<td>−2.1</td>
<td>1.4</td>
<td>−1.7</td>
</tr>
</tbody>
</table>

### 3.2. Pain

Comparing the KT and the no-KT group results for pain scores assessed using a 10 level visual analogue scale (VAS) are shown in Fig. 5.

### 3.3. Trismus

Baseline mouth opening values did not differ significantly in both groups. Comparing KT and no-KT group Table 3 shows the difference between mean sum of all inter inter-incisal distance measurements at baseline and T1, T2, T3, T4 for all patients. Compared to the baseline there is an increase in mouth opening at T2, T3 and T4 for the KT group (0.19 cm ± 0.68; 0.27 cm ± 0.63; 0.47 cm ± 0.57) while the no-KT group is decreasing (−0.01 cm ± 0.42, −0.18 cm ± 0.55, −0.17 cm ± 1.44). Results are not statistically significant (p > 0.05).

### 3.4. Subjective feeling

Results of subjective feelings are shown as sum of all scores for all patients at the specific measurement times in percentage. Reviewing patients satisfaction showed almost no difference between the KT and the no-KT group postoperatively (T0) and the day after the operation (T1) (Fig. 6). Two, three and four days after operation patients satisfaction is higher in the KT group (very satisfied: T2: 60%, T3: 67%, T4: 73%; satisfied: T2: 40%, T3: 27%; T4: 13%; not satisfied T2: 0%, T3: 7%, T4: 13%) than in the no-KT group (very satisfied: T2: 20%, T3: 27%, T4: 47%; satisfied: T2: 40%, T3: 40%, T4: 40%; not satisfied T2: 40%, T3: 33%; T4: 13%). Results for subjective KT evaluation are shown in Fig. 7.

### 4. Discussion

ZO fractures account for a significant component of facial trauma, affecting a young and economically active subset of the population. Postoperative swelling, pain and trismus are common events after ZO surgery affecting the social and working life of the patients (Calderoni et al., 2011, Trivellato et al., 2011).

There are many studies on the control of postoperative oedema in maxillofacial surgery. In third molar surgery, the use of laser is a...
relatively new method reducing postoperative discomfort, especially swelling (Osunde et al., 2011). It is believed that laser irradiation induces an increase in number and diameter of lymph vessels, with a simultaneous decrease of blood vessel permeability. However, its use in midface surgery has not been investigated yet.

Ice therapy is a simple, cheap, repeatable modality. Its therapeutic effects are due to changes in blood flow, consequent vasoconstriction and reduced metabolism, therefore reducing bacterial growth. However, data concerning the effect of cryotherapy on swelling are controversial (Greenstein, 2007, Rana et al., 2011, 2012).

Unfortunately, comparison of published drug studies is difficult because of the variability in parameters and methods used for each study.

The use of steroids is common in oral and maxillofacial surgery (Assimes and Lessard, 1999). However, except for the use of steroids after third molar extraction (Buyukkurt et al., 2006; Grossi et al., 2007), little has been published about potential benefits after midfacial fracture treatment. Patients with ZO fractures usually have swelling, pain and trismus before the operation, requiring longer treatment than for the removal of third molars. Therefore, to benefit from steroid medication, patients with facial fractures ought to get higher doses than patients undergoing third molar surgery.

The use of non-steroid anti-inflammatory drugs (NSAID) has been investigated with regard to reducing pain and inflammation. In the current literature, it is apparent that the combination of another drug with an NSAID is often more effective in controlling postoperative pain and swelling in head and neck surgery than a NSAID alone (Kim et al., 2009).

Although the use of antibiotics for the control on significant postoperative swelling and haematoma after head and neck surgery has been investigated, there is no consensus on the optimal regimen. Furthermore, the use of antibiotics for prophylaxis in the prevention of postoperative infections remains controversial (Greenstein, 2007, Rana et al., 2011).

**Table 3**

<table>
<thead>
<tr>
<th>Mean sum IID (cm)</th>
<th>KT group</th>
<th>no-KT group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean</td>
<td>SD</td>
<td>Mean</td>
</tr>
<tr>
<td>T1–T0 (BL)</td>
<td>-0.05</td>
<td>0.63</td>
</tr>
<tr>
<td>T2–T0 (BL)</td>
<td>0.19</td>
<td>0.68</td>
</tr>
<tr>
<td>T3–T0 (BL)</td>
<td>0.27</td>
<td>0.63</td>
</tr>
<tr>
<td>T4–T0 (BL)</td>
<td>0.47</td>
<td>0.57</td>
</tr>
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</table>

**Fig. 5.** Mean and 95% CI of VAS scores for all patients at six specific measurement times comparing KT (black error-bars) and the no-KT group (grey error-bars). Note, that for both groups patients scored moderate pain or less (VAS <5). There was no statistically significant difference between the two groups at any time.

**Fig. 6.** Satisfaction score for all patients in percentage at six specific measurement times comparing the KT group (panel A) and the no-KT group (panel B). Note, that on days two, three and four after operation patient satisfaction was higher in the KT than the no-KT group.

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surgery is common, antibiotic therapy in ZO surgery is controversial. Knepil et al. highlight the low incidence of infections following surgery for ZO fractures (Knepil and Loukota, 2010). The investigators think that avoiding a transoral approach allows for a clean operation, making prophylactic antibiotics unnecessary. With any medication helping to reduce postoperative side effects adverse effects and serious complications may follow. Emerging cases of drug allergies and drug-associated side effects are focussing more attention on alternative methods.

In an initial study, Szolonoky et al. investigated the efficacy of manual lymph drainage (MLD) after third molar extraction. Using reproducible facial measurement and a VAS pain scale, they demonstrated that MLD promoted an improvement of lymph circulation and worked in an adjunctive role for a significant reduction of postoperative swelling and pain (Szolnoky et al., 2007).

Although KT has been increasingly used in the rehabilitation protocols and prevention of sport injuries, there is no clear evidence regarding potential mechanisms underlying the beneficial effects of KT. While promising anecdotal reports and case studies exist, there is a need for evidence-based studies with good methodological quality showing beneficial clinical effects (Williams et al., 2012). KT has a potential influence on the reduction of swelling and haemorrhage.

Studies performed on the treatment of neoplastic or cancer related lymphoedema, have no evidence-based significance (Chou et al., 2012, Tsai et al., 2009).

To the best of our knowledge clinical studies using KT for postoperative management of swelling, pain and trismus after ZO surgery have not been performed. The results of this study show that the application of KT after ZO surgery has a significant influence on tissue reaction and swelling with an average cost for unilateral taping below one Euro per patient. The primary endpoint, increase of swelling was significantly lower for the KT group than the no-KT group. After operation the maximum swelling usually occurs 2nd to 3rd day after operation, which goes along with the results of our control group. However, using KT mean peak swelling was reached after 0.5 days with significant lower values compared to the no-KT group. Furthermore, reduction of swelling was faster in the KT group compared to the no-KT group, decreasing the swelling by more than 60% during the first 2 days after surgery. This might be due to KT stretch capabilities, thickness and adhesion allowing approximating the quality of the skin. The material used for KT is an elastic cotton tape with a non-allergenic head sensitive adhesive layer. KT has been designed to allow 30–40% longitudinal stretch. By extending and rotating the muscles the skin of the area to be treated is stretched. KT is than applied to the skin with a slight stretch. When the body parts return to their starting points the tape

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**Fig. 7.** Subjective KT evaluation score for all patients of the KT group (n = 15) in percentage. Shown is patient evaluation if they found the KT disturbing (panel A) and if KT affected them in their movements (panel B).

**Fig. 8.** Convolutions below the taped area caused by the elasticity of the applied tape subsequently recoiling back to its original length following the application. It’s believed that these convolutions increase the interstitial space between the skin and underlying connective tissue thus promote the follow of blood and lymphatic fluid.
subsequently recoils back to its original length following the application. This creates a pulling force to the skin forming convolutions below the taped area (Fig. 8). It is believed that these convolutions increase the interstitial space between the skin and underlying connective tissue, thus promoting the flow of blood and lymphatic fluid. In the head neck region, as performed in this study, changes in the length of tissue and the tape are extreme around a flexed, extended or rotated joint. Major convolutions could be recognized. As proposed by Shim et al. in a pilot animal study these emerging wrinkles are not only indenting, but also elevating the skin (Shim et al., 2003). These investigators propose a positive effect on the formation of lymph by opening micro valves in the initial lymphatic vessels, therefore generating appropriate dynamic pressure variation and sufficient periodic compression and decompression of superficial and deep initial lymphatics.

According to some investigators KT facilitates the decrease of pain by pressure reduction on nociceptors (Kase et al., 1996). In this study no reduction of pain for the KT group compared to the no-KT group was demonstrated. Other studies performed (Gonzalez-Iglesias et al., 2009; Thelen et al., 2008) are in agreement with these findings. The results of this study show patients scored moderate pain or less in both groups (VAS < 5) for all six specific measurement times. This might be due to the standardized analgesic drug therapy protocol which both study groups received postoperatively and during their hospital admission. In order to make an evidenced statement, further investigation needs to be performed, eliminating the standardized analgesic and providing rescue drugs.

Using KT, patients mouth opening increases faster after the operation than in the no-KT group. These results are as seen in our subjective findings. Patients in the KT group had higher satisfaction after operation compared to the no-KT group. This might be because the swelling resolves faster, taking the tension from the skin. In addition, KT effect detracts from pain and perception. Movement stresses KT, it only partially adjusts its length to that of the skin, and thus deforms the skin. This constant stimulus stimulates the skin and diverts patients’ recognition, but our study design was not designed to exclude possible placebo effects caused by the KT.

Although friction resulting from the elasticity of the tape could cause skin irritation and some adhesives might provoke allergies to some patients, we had no incidence of adverse reactions in our study, but these reactions should be considered for different types of tape. To the best of our knowledge, there are no reported cases of severe allergic reaction to KT application.

The assessment of facial volume reduction is one of the biggest obstacles for an objective and reliable demonstration of a used method. Numerous methods have been tried, most of which are imprecise, complex, expensive or difficult to standardize (Bjorn et al., 1954; Milles et al., 1985; Van Gool et al., 1975). To quantify the changes in facial volume we used a modified method of linear measurements in our study. By applying a series of data points, we utilized defined landmarks covering the whole facial area of interest. By marking segments endpoints, great care was taken to always measure the same distances. Measurements were only carried out by one of the investigators thus reducing unwanted measurement variance.

5. Conclusion

The use of KT appears promising, because it is simple to carry out, less traumatic, economical, can be performed everywhere in the world, free from side effects on the body. Even when swelling persists, KT gives patients the impression of a minor swelling detracting them from their pain and morbidity. Further studies have to be performed to find out if KT can reduce or replace the need for additional medications such as the use of steroids.

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Conflicts of interest

We declare that we have no conflicts of interest.

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