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Rehabilitation of Neurosensory Changes in the Infraorbital Nerve Following Zygomatic Fractures

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ABSTRACT

The purpose of the study was designed to clarify the modern trends of neurosensory rehabilitation in treatment of infraorbital nerve changes following zygomatic fractures. In this respect, neurosensory function was assessed with calibrated nylon monofilaments, electrical stimulation, heat detection thresholds and response to pin prick in the infraorbital, supraorbital and mental nerve regions in both sexes. Subjects, thirty males and females were the same degree of fractures severity according to Henderson's classification (grade1, 2& 3), their age ranged from 25-45years old and their weight ranged from 60-88Kg.They were randomly divided into two equal groups (G1and G2). G1**,** consists of 15 patients of both sexes and was treated by surgical procedures (reduction and fixation) and G2 consists of 15 patients was treated by the same surgical procedures and electrical neuromuscular stimulation with exercises therapy program. Vital signs as blood pressure, body temperature, pulse rate and respiratory rate measured before and after the treatment sessions. Assessments, visual analogue scale was used to measure degree of pain, Semmes-Weinstein monofilaments was used to measure the light touch sensation, Aesthesiometer 2 point calliper was used to measure the two point discrimination sensation, Peltier probe was used to measure heat detection sensation. Moreover, by the use an ascending test of phyaction guidance-c system to measure the electrical detection threshold. Statistically the results for all groups were analyzed by t-test to compare the differences between the two groups. The statistical package of social sciences (SPSS, version10) used for data processing using the p-value 0.05 as a level of significance. Results, showed that there were significant improvements in all variables in both groups in a favour to G2. Therefore, we concluded that, the use of surgical procedures combined with neuromuscular electrical stimulation and exercises program were the good method and open a new link to improve the recovery of infraorbital nerve sensory changes following zygomatic fractures.

Key words: Infraorbital Nerve, Zygomatic Fractures, Neuromuscular Electrical Nerve Stimulation, Aesthiometer, Pain and Sensory Dysfunctions.

Introduction

The zygomatic bone provides prominence to the cheek which leads to its increased chances of fracture and the infraorbital nerve is often involved in the trauma to the zygomatic complex resulting in the sensory disturbance of the area innervated by itLund, (1971).

The zygoma articulates with the frontal sphenoid, temporal and maxillary bones and contributes significantly to the strength and stability of the midface (Finlay *et al.*, 1984).

The zygoma may be separated from its four articulations. This is called a zygomatic complex fracture. The terms trimalar or tripod fracture are therefore inaccurate. These terms reflect an inability to easily identify the orbital (zygomaticosphenoid) portion of the injury before the advent of computed tomography. The zygomatic arch may be fractured independently or as part of a zygomatic complex fracture (Lund, 1971).

The zygoma has four projections, which create a quadrangular shape the frontal, temporal, maxillary, and the infraorbital rim. The zygoma articulates with four bones: the frontal, temporal, maxilla, and sphenoid(Jungell and Lindqvist, 1987).

The zygomatic arch includes the temporal process of the zygoma and the zygomatic process of the temporal bone. The glenoid fossa and articular eminence are located at the posterior aspect of the zygomatic process of the temporal bone(Jungell and Lindqvist, 1987).The infraorbital nerve (IO) passes through the orbital floor and exits at the infraorbital foramen. It provides sensation to the anterior cheek, lateral nose, upper lip, and maxillary anterior teeth. Muscles of facial expression originating from the zygoma include the zygomaticus major and labiisuperioris. They are innervated by cranial nerve VII (Ellies *et al.*, 1985). Following orbitozygomatic

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complex (OZC) fractures, the reported incidence of long-term sensory disturbances of the inferaorbital nerve varies between 24% and 50% (Ellies *et al.,* 1985).

Zygomatic fractures are not life threatening and are usually treated after more serious injuries are stabilized and swelling has resolved 4 to 5 days after injuries. Initial evaluation of the patient with a zygomatic fracture includes documentation of the bony injury and the status of surrounding soft tissue (eyelids, lacrimal apparatus, canthal tendons, and globe) and cranial nerves II to VI (Becelli *et al.,* 2002).

Also, Visual acuity and the status of the globe and retina should be established; an ophthalmologist should be consulted for suspected In a recent surveillance study from(Lund, 1971) reported an annual incidence of 139.4 cases per 100,000 in females and 67.2 cases per 100,000 in males, with a female to male ratio of 2.07 29. Overall prevalence of 3.0–5.8% among women and 0.6–2.1% among men have been found in general population(Jungell and Lindqvist, 1987).

Treatment of zygomatic fractures must be based on a complete preoperative evaluation. This includes a CT scan with axial and coronal images to fully appreciate the nature of the injury. Management of zygomatic complex and zygomatic arch fractures depends on the degree of displacement and the resultant esthetic and functional deficits. Treatment may therefore range from simple observation of resolving swelling, extraocular muscle dysfunction, and paresthesia to open reduction and internal fixation of multiple fractures (Essick,1992).

Some studies on the long-term effects of treatment methods on sensory function have suggested that the treatment of isolated simple OZC fractures consisting of open reduction and miniplate fixation, yields better recovery of sensory function than (i) open reduction and interosseous wire fixation (ii) open reduction and support with an intra-antral Foley catheter or (iii) closed reduction without fixation (Man and Bax,1988).

The aims of the present study were to investigate sensory changes in the IO nerve following zygomatic fractures employing advanced qualitative and quantitative sensory testing (thermal, electrical and mechanical) , over a 6-month period. These parameters were correlated to the fracture severity and treatment modality. The advantage of multimodal testing is the ability to differentiate between largely mechanosensitive neurons (AB fibers) by employing electrical stimuli and fine nylon filaments, pinprick and thermal selectivity activate nociceptors (AD and C fibers) . In addition, we assessed the presence of chronic orofacial neuropathic pain at 6 months.

Material and Methods

Patients admitted to the department of oral and maxillofacial surgery, King Khalid hospital, Najran, with isolate unilateral fracture of the zygomatic arch, zygomatic complex, or rim were the patients of our study.

The patients were examined as soon as possible following the injury (from 3-12 hours), then at 1 and 6 months after surgery. Following the initial assessment, the patients underwent surgical management in the department of Oral and Maxillofacial Surgery within 5 days. The evaluator was blinded as to the surgical management of the patient, and the surgeon was not allowed access to the results of the sensory assessment.

Fracturers were diagnosed clinically and radiologically (X-ray or CT). Indications for reduction of fractures are well documented and are based on the signs and symptoms and functional impairment. These signs and symptoms include visible facial asymmetry, significant functional disturbance of mandibular movement, disturbance of vision (diplopia) or eye movements, and IO nerve dysfunction. A lack of these signs is therefore a contraindication for surgical intervention. In all treated cases closed reduction was attempted, and if this resulted in a stable reduction of the fragments , when reduction was unstable, the zygomaticofrontal suture was surgically exposed and with wires or a miniplate . Postoperatively, cases were clinically and radiologically. Sensory threshold was quantified for each of the modalities bilaterally in the supraorbital (SO), IO and mental (MNT) nerve regions.

Thirty consecutive patients following orbitozygomatic complex (OZC) fractures with regard to the sensory function of the inferaorbital nerve. Mean patient's age was 36.6 years with a median of 35.5 years. Ten of the patients were female and ten male.

Inclusion criteria:

Patients were selected if (1) they had a unilateral fracture, because the appropriate no affected site served as an internal control in two-point discrimination tests, (2) their fracture was of type III, IV and V according to Henderson's classification and (3) appropriate treatment with respect to type of fracture was employed, i.e., the patient did not refuse the indicated surgical intervention.

Exclusion criteria:

Patients with multiple facial fractures were excluded. These signs and symptoms include visible facial asymmetry, significant functional disturbance of mandibular movement, disturbance of vision (eg, diplopia) or of eye movements, and infraorbital nerve dysfunction. Severe degree of disabilities, patients having complications, psychological unstable ,non co-operative patients during assessment of the research.

A lack of these signs is therefore a contraindication for surgical intervention The patients were examined as soon as possible following the injury, then at 1 and 6 months after surgery.

Following the initial assessment, the patients underwent surgical management within 1 or 2 days.

Fractures were diagnosed clinically and radiographically. Routine radiographs included a Water's view, an submental vertex (SMV), and computed tomography (CT) are usually performed

Indications for reduction of fractures are well documented and are based on the signs, symptoms, and functional impairment.

They had no signs of aphasia , they had sufficient vision and hearing , the patients were randomly and equally divided into two groups. Group (1): consists of 15 patients of both sexes who received surgical interference only. Group (2): consists of 15 patients of both sexes who received surgical interference, neuromuscular electrical nerve stimulation (NMES)20Hz,15min.50%intenistyand strengthening exercises, Faciltatory techniques (brief icing, tapping and scratching) on the affected area of face and postural correction exercises of head and neck. Time of exercises 30 min, three times per week, day after day.

The neurosensory evaluation:

While the patient was sitting comfortably in a dental chair, the examiner tested in turn (1) the mechanical sensation, (a) light touch sensation was tested using small kit of semmes-weinnstein monofilament (SWMs) (North Coast Medical, Inc., San Jose, CA, USA), (b) two point discrimination was examined with the Aesthiometer 2 points (North Coast Medical, Inc.) a form of sharp pointed caliper, by which higher threshod afferent fibres related to touch sensation and nociceptive afferents may be stimulated, (2) heat sensation (hot and cold) by ethylchloride saturated dental swab, (3) pain sensation by gauge needle (4) electrical detection sensation. Patients were asked whether they had any altered sensation in facial areas innervated by the infraorbital nerve, and the reports were classified according to the following definitions. Dysaesthesia was characterized by altered quality of sensation that include an uncomfortable component. Anaesthesia was related to the complete absence of sensation.

Mechanical detection threshold:

The orofacial region is very sensitive to mechanical stimulation, and standard sets, we employed proline monofilament (Ethicon, Somerville) that exerted clinically relevant forces for sensory testing in the face. To ensure standardization between monofilament we tested the force applied by different lengths of monofilament 10 times in 5 filament of each length.

Mechanical detection was assessed in the patients by administering the series of filaments 2 times each in ascending order. With eyes closed, patients indicated each time a filament touch was detected in the MNT, IO and SO areas of distribution (Eliav *et al.,* 2003).

Heat detection threshold:

Detection threshold for heat stimuli were evaluated by a 5mm water cooled peltier probe using a staircase paradigm in which stimulus intensity (temperature) was alternately increased on successive trials until a sensation was evoked, and decreased until no sensation was perceived. After each change in direction, the amount of stimulus change from each trial was reduced by 50%, and the ascending and descending trials were repeated until this increment was reduced to 0.10c. In this series the starting temperature was 30oc and increased gradually with a mean of 32.5^{o}c (Eliav *et al.,* 2003).

In order to test cold sensation, ethyl chloride vapour was sprayed onto a spherical dental cotton bud (diameter:5mm). After ice crystals had been formed, the bud was placed on the site for at most 1second. As determined by a small type k thermocouple (Fluke 80 TK, Eindhoven, The Netherlands), a new steady state temperature of the skin was reached within just a second. The drop in temperature varied within a range from 22 to 24oc at the interface between cotton bud and skin. In addition to thermoreceptors, nociceptive afferents may have been stimulated. Sensory function related to temperature was considered to be normal if two successive positive responses in four tests were obtained (50%) (Eliav *et al.,* 2003).

Electrical detection threshold:

For electrical detection threshold, continuous trains of constant- current electrical stimuli were delivered to the skin through 10mm diameter spherical gold- plated electrodes spaced 25mm apart. Stimulus frequency was 20Hz with a 50% duty cycle. Polarity of the electrodes were randomized. Detection thresholds were assessed by an ascending method of limits, phyaction Guidance-C System, Bilzen, Belgium, SN62851. Stimulating current was increased at a fixed rate until the subject indicated detection. Three detection thresholds were evaluated for each location and the mean calculated and used for data analysis. Results are expressed as ratios between the injured side and the control side (Eliav *et al.*, 2003).

In normal situation the ratio would not be expected to be different from a value of higher ratios indicate relative hypothesia of the injuried side and lower ratios indicate hyperesthesia.

Two point discrimination:

It was examined with Aesthesiometer 2 point, each of the tests consists of four alternating series with either ascending or descending increments with a successively longer or shorter pin distance in the device, during which the patient reported on a present or absent sensation of two separate points of stimulation. A test series was terminated after a response reversal, i.e. when a particular type of response (positive/negative) on successive increments. The threshold for two point discrimination was calculated as the mean of 8 pin distances around the four reversals from the test series(Eliav *et al.*, 2003).

Reaction to pinprick:

The tip of a 0.2mm diameter blunted acupuncture needle was pushed against the patients skin until the needle slightly bends (the skin was dimpled but not penetrated). Under these conditions the bended needle exerts a mean force of 10 (±0.5) Newton as measured on a laboratory scale. The patient graded the sensation on a 100mm visual analog scale (VAS) where 0 represented no sensation and 10 represented the strongest pain. Results were recorded as the difference in VAS values between the control and injuriedsides (Eliav *et al.*, 2003).

Statistical analysis:

The results of two groups were statistically analyzed by t-test to compare the differences within each group and between the two groups. The statistical package of social science (SPSS version 10) was used for data processing the P-value 0.05 level significance.

Data Summarized by using:

The arithmetic mean average describing the central tendency of observation where The standard deviation (S.D) used to measure to described the results around mean where paired and unpaired t-test was performed to determine the significance difference pre and post within the same group and the differences between the two groups.

Results:

Subjects Characteristics:

Thirty males and females subjects participated in the study, their ages ranged between (25 – 45) years with mean age (36.4±6.6) years, their weights ranged between (60 – 88) kg with mean weight (75 ±7.7) kg. The subjects were divided into two equal groups. Each group consisted of fifteen subjects. The characteristics of subjects in each group are shown in Table (1) and Fig(1).

Table 1: Characteristics of subjects in each group.

	Group 1		Group 2		P	Sig.
	Mean	S.D	Mean	S.D		
Age (yrs)	36.7	±6.3	36.1	±7.2	0.81	NS
Weight (Kg)	75.3	±6.8	74.8	±8.7	0.87	NS

P >0.05: indicates Non significance.NS: Non significance.

The independent t test between the two groups showed no significant differences between groups or within groups of age (where P value was 0.81) and weight (where P value was 0.87), as shown in Table (1) and fig(1&2).

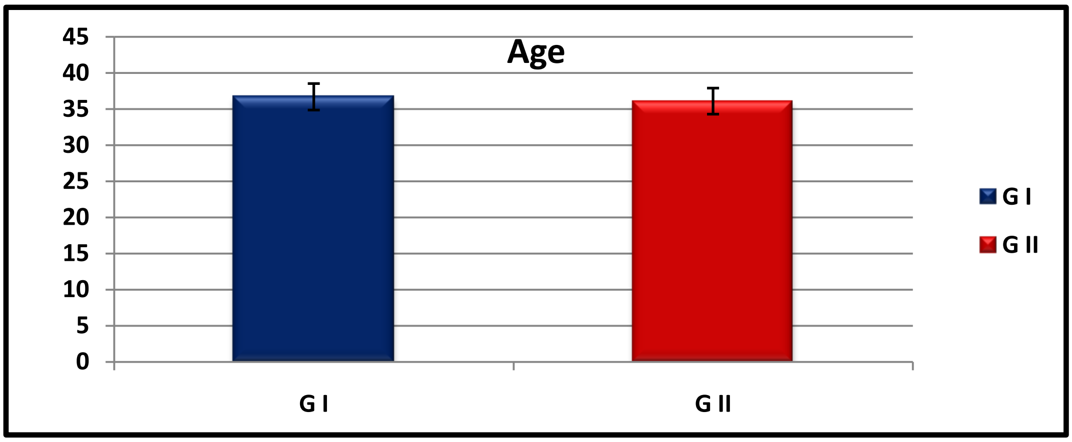

Fig. 1: Showing the age characteristics of subjects in each group.

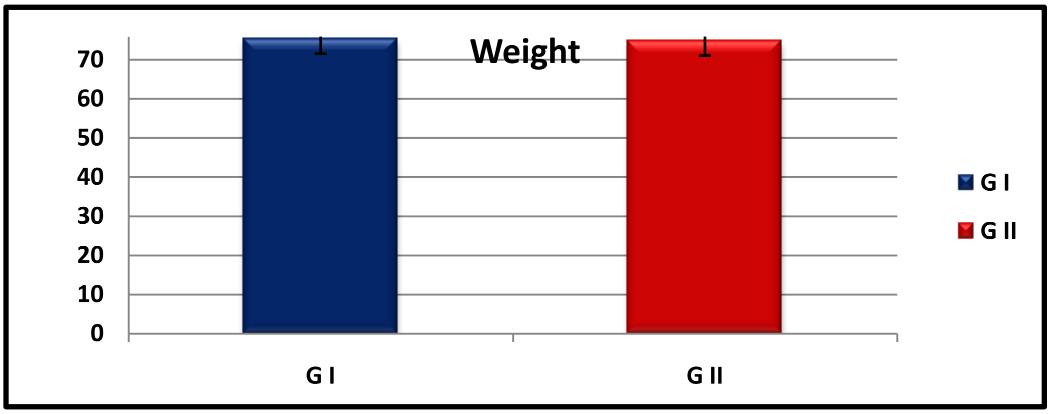

Fig. 2: Showing the weight characteristics of subjects in each group.

Differences in Light mechanical detection threshold test between the two groups:

The results of the independent t-test between the two groups revealed that there were no significant differences in the light mechanical detection test measured before the experimental trial where that value was -0.38, while P was 0.707, and moderate significant differences when measured post experimental trial where the t value was 3.95, while P was 0.001as shown in Table (2) andFig (3).

Table 2: Results of the t-test between the two groups of Light mechanical detection threshold test measured before and after the experimental trial.

		Mean	SD	T	P
Pre-test	G I	5.5	±0.5	-0.38	0.707
	GII	5.2	±0.5		
Post-test	G I	10.2	±0.5	3.95	0.001**
	GII	15.7	±0.3		

Differences in Light mechanical detection threshold test within the two groups:

The results of the dependant t-test between pre and post test of group I revealed that there were significant differences in the light mechanical detection test where the t value was 2.82, while P was 0.014, and moderate significant differences between pre and post test of group II where the t value was 10.46, while P was 0.001 as shown in table (3) and Fig. (3).

Table 3: Results of the t-test within the two groups of Light mechanical detection threshold test measured before and after the experimental trial.

		Mean	SD	T	P
Group I	Pre	5.5	±0.5	2.82	0.014 *
	Post	10.5	±0.5		
Group II	Pre	5.2	±0.5	10.46	0.001**
	Post	15.7	±0.3		

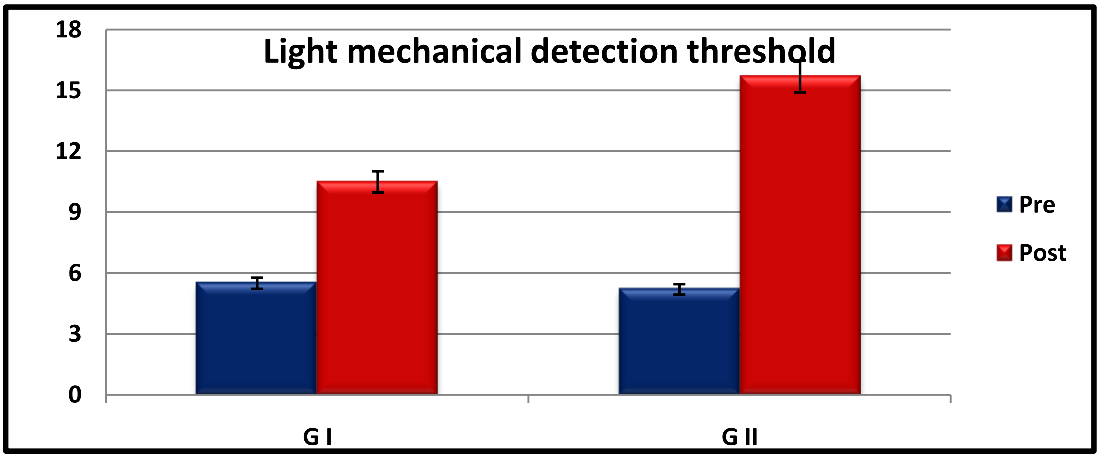

Fig. 3: The results of Light mechanical detection threshold of test in each group.

Differences in Two point discrimination test between the two groups:

The results of the independent t-test between the two groups revealed that there were no significant differences in two point discrimination test measured before the experimental trial where the t value was -0.414, while P was 0.682, and moderate significant differences when measured post experimental trial where the t value was -8.78, while P was 0.001as shown in Table (4) and Fig.(4).

Table 4: Results of the t-test between the two groups of Two point discrimination test measured before and after the experimental trial.

		Mean	SD	T	P
Pre-test	G I	8.7	±1.5	-0.414	0.682
	GII	8.9	±1.1		
Post-test	G I	10.8	±1.6	-8.78	0.001**
	GII	15.2	±1.1		

Differences in Two point discrimination test within the two groups:

The results of the dependant t-test between pre and post test of group I revealed that there were significant differences in two point discrimination test where the t value was -12.91, while P was 0.01, and moderate significant differences between pre and post test of group II where the t value was -23.44, while P was 0.001 as shown in table (5) and Fig. (4).

Table 5: Results of the t-test within the two groups of two point discrimination test measured before and after the experimental trial.

		Mean	SD	T	P
Group I	Pre	8.7	±1.5	-12.91	0.01*
	Post	10.8	±1.6		
Group II	Pre	8.9	±1.1	-23.44	0.001**
	Post	15.2	±1.1		

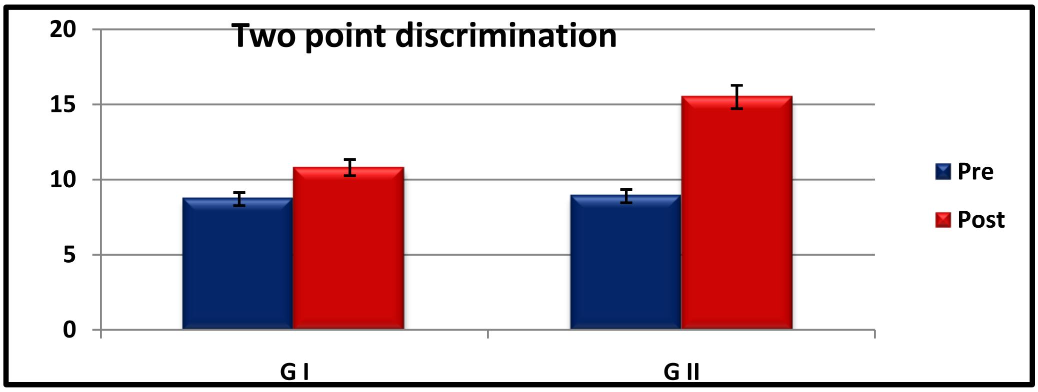

Fig. 4: Showing the results of Two point discrimination test in each group.

Differences in Electrical detection threshold test between the two groups:

The results of the independent t-test between the two groups revealed that there were no significant differences in electrical detection threshold test measured before the experimental trial where the t value was -0.542, while P was 0.592, and moderate significant differences when measured post experimental trial where the t value was -15.944, while P was 0.001as shown in Table (6) and Fig. (5).

Table 6: Results of the t-test between the two groups of measured Electrical detection threshold test before and after the experimental trial.

		Mean	SD	T	P
Pretest	G I	20.3	±0.3	-0.542	0.592
	GII	21.3	±0.3		
Post-test	G I	15.8	±0.4	-15.944	0.001
	GII	8.8	±0.3		

Differences in Electrical detection threshold within the two groups:

The results of the dependant t-test between pre and post test of group I revealed that there were significant differences in electrical detection threshold where the t value was -12.91, while P was 0.01, and moderate significant differences between pre and post test of group II where the t value was -23.44, while P was 0.001 as shown in Table (7) and Fig. (5).

Table 7: Results of the t-test within the two groups of Electrical detection threshold measured before and after the experimental trial.

		Mean	SD	T	P
Group I	Pre	20.3	±0.3	-12.91	0.01*
	Post	15.8	±0.4		
Group II	Pre	21.3	±0.3	-23.44	0.001**
	Post	8.8	±0.3		

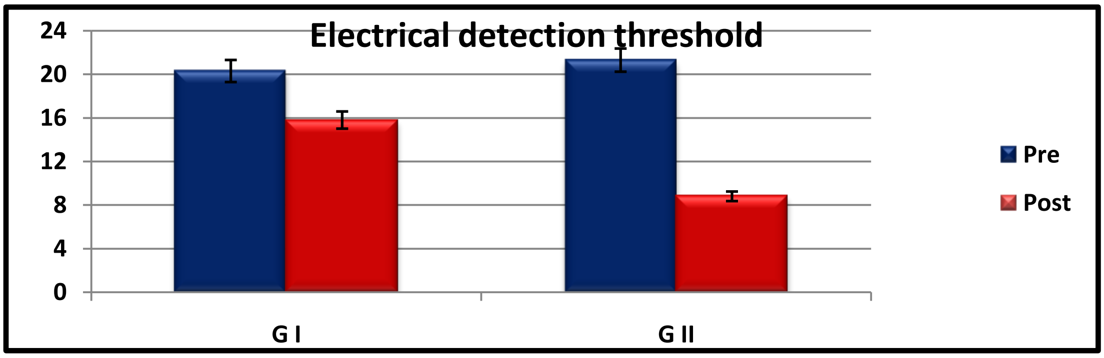

Fig. 5: Showing the results of Electrical detection threshold in each group.

Differences in Reaction to painprick between the two groups:

The results of the independent t-test between the two groups revealed that there were no significant differences in reaction to pinprick measured before the experimental trial where the t value was 0.6, while P was 0.97, and moderate significant differences when measured post experimental trial where the t value was -6.38, while P was 0.001as shown in Table (8) and Fig. (6).

Table 8: Results of the t-test between the two groups of Reaction to painprick measured before and after the experimental trial.

		Mean	SD	T	P
Pre-test	G I	8.64	±0.3	0.6	0.97
	GII	8.04	±0.3		
Post-test	G I	6.4	±0.4	-6.38	0.001**
	GII	4.7	±0.3		

Differences in Reaction to painprick within the two groups:

The results of the dependant t-test between pre and post test of group I revealed that there were significant differences in reaction to pinprick where the t value was -9.51, while P was 0.01, and moderate significant differences between pre and post test of group II where the t value was -14.4, while P was 0.001 as shown in Table (9) and Fig. (6).

Table 9: Results of the t-test within the two groups of Reaction to painprick measured before and after the experimental trial.

		Mean	SD	T	P
Group I	Pre	8.64	±0.3	-9.51	0.01*
	Post	6.4	±0.4		
Group II	Pre	8.04	±0.3	-14.4	0.001**
	Post	4.7	±0.3		

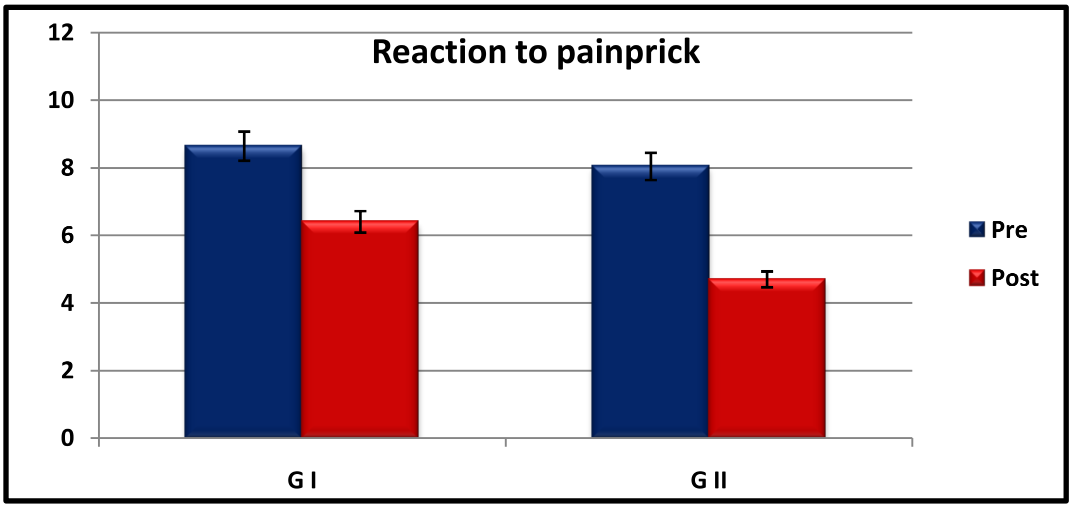

Fig. 6: Showing the results of Reaction to painprickin each group.

Differences in Heat detection threshold test between the two groups:

The results of the independent t-test between the two groups revealed that there were no significant differences in heat detection threshold before the experimental trial where the t value was -0.374 , while P was 0.711, and moderate significant differences when measured post experimental trial where the t value was -15.19, while P was 0.002 as shown in Table (10) and Fig.(7).

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Table 10: Results of the t-test between the two groups of Heat detection threshold test measured before and after the experimental trial.

		Mean	SD	T	P
Pre-test	G I	32.6	±0.1	-0.374	0.711
	GII	33.6	±0.1		
Post-test	G I	25.9	±0.1	-15.19	0.002
	GII	19.5	±0.1		

Differences In Heat detection threshold test within the two groups:

The results of the dependant t-test between pre and post test of group I revealed that there were significant differences in heat detection threshold where the t value was -15.9 while P was 0.01 and moderate significant differences between pre and post test of group II where the t value was -29.79, while P was 0.001 as shown in Table (11) and Fig. (7).

Table 11: Results of the t-test within the two groups of Heat detection threshold test measured before and after the experimental trial.

		Mean	SD	T	P
Group I	Pre	32.6	±0.1	-15.9	0.01*
	Post	25.9	±0.1		
Group II	Pre	33.6	±0.1	-29.79	0.001**
	Post	19.5	±0.1		

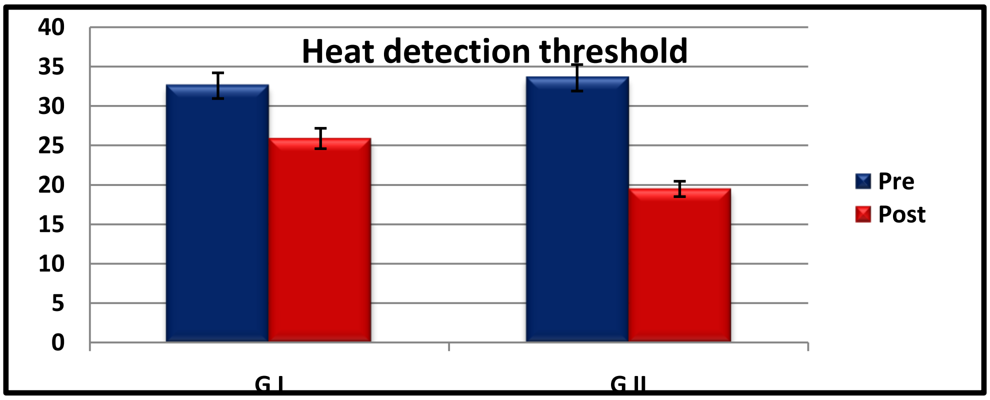

Fig. 7: Showing the results of Heat detection threshold test in each group.

Differences in Cold detection threshold test between the two groups:

The results of the independent t-test between the two groups revealed that there were no significant differences in cold detection threshold measured before the experimental trial where the t value was -0.132 , while P was 0.896 and moderate significant differences when measured post experimental trial where the t value was -2.93, while P was 0.007 as shown in Table (12) and Fig.(8)

Table 12: Results of the t-test between the two groups of Cold detection threshold test measured before and after the experimental trial.

		Mean	SD	T	P
Pre-test	G I	10.1	±0.1	-0.132	0.896
	GII	9.8	±0.1		
Post-test	G I	5.9	±0.1	-2.93	0.007**
	GII	3.1	±0.1		

Differences in Cold detection threshold test within the two groups:

The results of the dependant t-test between pre and post test of group I revealed that there were significant differences in cold detection threshold where the t value was -13.26 while P was 0.01 and moderate significant differences between pre and post test of group II where the t value was -20.58, while P was 0.001 as shown in Table (13) and Fig. (8).

Table 13: Results of the t-test within the two groups of Cold detection threshold test measured before and after the experimental trial.

		Mean	SD	T	P
Group I	Pre	10.1	±0.1	-13.26	0.01*
	Post	5.9	±0.1		
Group II	Pre	9.8	±0.1	-20.58	0.001**
	Post	3.1	±0.1		

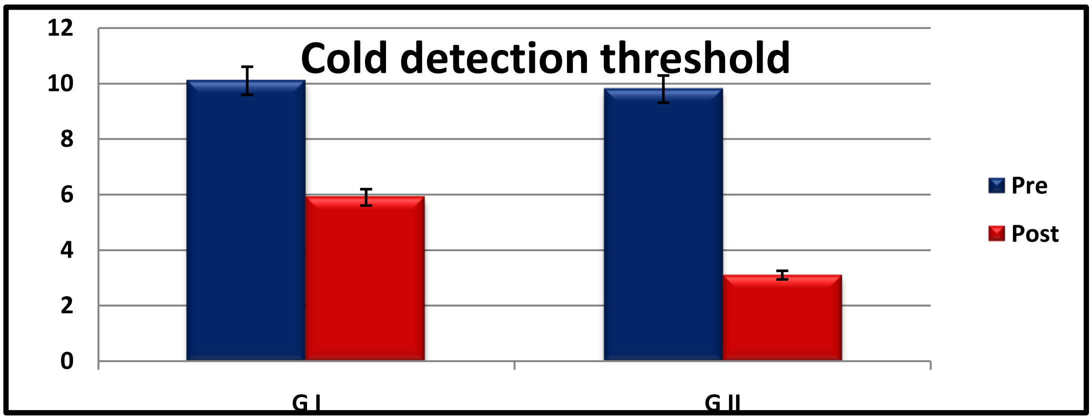

Fig. 8: Showing The results of Cold detection threshold test in each group.

Discussion:

Orbitozygomatic complex fractures are common injuries of the craniumaxillofacial skeletal. The classification system designed by Henderson is based on anatomical types and on predicted stability uponreduction.Types III, IV and VII frequently require fixation of the main body of the zygoma, whereas in types I, II, V and VI no displacement of the main body of the zygoma occurs. Sequelae of orbitozygomatic complex fractures include effects on the orbital contents and facial aesthetics and are an indication for surgical treatment[4].

Sensory disturbances in the distribution of the infraorbital nerve are almost always present in orbitozygomatic fractures (Ross *et al.,* 1991) The nerve can be damaged through oedema, ischaemia, compression, traction and/or rupture by the bony spicules of a disrupted orbital floor and/or sharp edge of the fracture line. According to the literature, the incidence of sensory disturbances in orbitozygomatic complex fractures in the immediate post-trauma period varies from 24% to 94% (Taicher *et al.,* 1993). Studies with the lowestincidence of sensory dysfunction use unrefined methods for sensory testing and tend to be retrospective.

However, the vast majority of patients will have neurosensory deficits in the function of the infraorbital nerve initially following orbitozygomatic complex fractures, because in 95% of orbitozygomatic fractures the fracture line involves the infraorbital foramen (Sehilli, 1990). Theoretically absence of neurosensory deficits implies that thefracture may be lateral, medial or posterior to the infraorbital groove or canal. All patients in our series had neurosensory deficits in the cutaneous distribution of the infraorbital nerve immediately after the trauma (Van Swearingen and Brach, 2003).

This can be explained by the relatively small number of patients and a limited number of different types of fracture. The long-term outcome of overall sensory function following orbitozygomatic complex fractures is in agreement with the results found by many authors (Lund, 1971), although we have to recognise that it is difficult, if not impossible, to compare the results among investigators, because there is no 'gold standard' for trigeminal nerve sensory testing .

Theclassification is based on the time course and completeness of sensory recovery and of necessity is a retrospective diagnosis. Sunderland's classification incorporates the features of Seddon's scheme but includes the amount of nerve tissue damaged and tissue still intact. Where neuropraxia or 1st degree lesions (type 1 and

2) exist, return to normal sensory function occurs within 1 week following nerve injury, 1st degree (type 3) takes 1 to 2 months for complete recovery, but is far earlier than can be explained by axonal regeneration. Complete recovery occurs in 2-4 months in an axonotmesis or 2nd degree nerve injury (Sunderland,1991).

A neurotmesis or 3rd, 4th or 5th degree nerve injury will show incomplete recovery of sensory function. Whereas 4th and 5th degree nerve injuries will have a poor prognosis for spontaneous recovery, 3rd degree nerve injury may show partial return of sensation within 3-5 months after the trauma (Zingg *et al.,* 1991).

The most likely cause for 3rd and 4th degree injuries include severe traction or compression. Not all nerve fibreshav the same susceptibility to compression injuries and ischaemia. The A/q (myelinated) fibres, responsible for mechanoception (touch), are more susceptible to compression and ischaemia than the A6 (myelinated) and C(unmyelinated) fibres (pain, temperature) (Wiesenbaugh, 1970).

Following a compression injury it is quite possible to have a deficit in mechanoception (light touch, moving touch),but intact nociception (pinprick) and thermal discrimination. In our study this phenomenon is reflected by the fact that in 10 % of the cases complete recovery of neurosensory function occurred for only some of the sensory modalities tested (Beurskens and Heymans, 2006).

Assuming that no transection or rupture of the entire infraorbital nerve trunk had occurred in our series, 36 % of patients had 3rd or 4th degree nerve injuries. Pathophysiologically this means loss of axonal continuity and endoneurial tubes. In 4th degree injury it also means interruption of the epineurium (Zachariades *et al.,* 1990).

Although it is impossible to translate these results to the initial trauma to the nerve, we can report that in at least 18 cases (36 %) these severe nerve injuries were present at the time of injury, as they were still present at 6-9 months after the trauma. This should influence the management of orbitozygomatic complex fractures in general, which has already been indicated by Jungell and Lindqvist (1987). In their study of 68 patients with zygomatic complex fractures, 9 patients (13.2 %) underwent surgery to the nerve and 6 patients experienced some improvement (Tajima,1997).

In another study, results from neuromicrosurgery to the inferaorbital nerve indicate a high degree of successful regeneration, with complete return of sensation in the distribution of the infraorbital nerve in 6 out of 7 cases (Souyris *et al.,* 1989). The indications for neuromicrosurgery are strongest for the neurotmesis or 3rd, 4th and 5th degree nerve injuries.

In cases with a zygoma fracture who were treate d only by bone elevation, 49% of all cases have permanent damage of the infraorbital nerve and at the same time > 50% of these patients have re-displacement of the zygoma as reported by[6]. In our series, the incidence was higher 77.8 %.

The reason for the damage to the nerve is not only the compression of the nerve for a short period by the displaced zygoma but probably also from additional splits of the orbital floor, along the infraorbital canal. With regard to fixation of unstable zygomaticfractures in relation to sensory recovery of the infraorbital nerve, miniplateosteosynthesis is recommended as opposed to wire fixation in all unstable zygomatic bone fractures where there is displacement (Manand Bax, 1988).

The incidence of postoperative infraorbital nerve sequelae is diminished by 50 % in unstable zygomatic fractures when treated by osteosynthesis with miniplates(Mozsary and Middleton,1938). This is in agreement with our findings of only 12.5 % persistent neurosensory deficits after open reduction and fixation with plate osteosynthesis.

The results regarding orbital floor reconstruction inwhich 25 % of the cases had persistent neurosensory deficits are in agreement with the study byKirkegaard *et al.* (1986), who found that 30 % of the patients had persistent reduced sensation in the infraorbital nerve distribution area. An incidence of 22 % of long-term neurosensory deficits in patients operated on for unilateral orbital floor fractures.

Although a neurosensory deficit in the distribution of the infraorbital nerve is not regarded as an indication for surgical treatment of orbitozygomatic complex fractures, in the absence of other significant symptoms, 44.4 % of the patients who did not undergo surgery sustained persistent neurosensory deficits. Surgery within 1 week after the trauma will improve the sensory function of the infraorbital nerve (Rohrich, 1991).

Despite the fact that not all of these patients will seek treatment for alteration in sensation, depending on the nature of the sensory disturbances, there may be a subgroup of patients who would benefit from early surgical treatment to prevent long-term nerve dysaesthesia. Furthermore, open reduction and fixation of an orbitozygomatic complex fracture offers a better prognosis for complete recovery of inferaorbital nerve function than elevation only with or without K-wire fixation (Nordgaard,1996).

Furthermore, early neuromicrosurgical intervention on the infraorbital nerve is indicated in one-third of all orbitozygomatic complex fractures, in particular in type III fractures, because of a high percentage of 3rd or 4th degree nerve injuries according to Sunderland's classification. Our study evaluated the recovery rate of subjective sensory modalities. A study including more quantitative neurological examination, such as cutaneous pressure thresholds (Coulson *et al.,* 2006). two-point discrimination and vibratory threshold measurements may give a clearer indication as to choice of treatment.

Our study showed that there was a strong relationship between the application of Neuromuscular electrical nerve stimulation and the improvement of pain parameter. These results were confirmed those obtained byBeurskens *et al.* (2006) who applied the electric stimulation with 20 Hz on two patients suffering from facial pain and there was a mild improvement in pain control.

In our study, we agree with other authors who mentioned that the Orofacial function in IO patients has some typical features in the mechanism of sensorydisturbance but differ individually according to the extent and location of trauma. After the assessment of different Orofacial parameters by EMG methods in 49 patients they found that, there was pain, dysesthesia and sensory changes. They related these changes to the facial sensation, eye movement, delayed reaction time, change detection to heat and cold (Schultze *et al.,* 1999).

The present study is in a accordance withFogaca *et al.* (2004) who concluded that NMES 0.4Hz with a physical therapy program seemed to address most of IO patients problems as function of orofacial and also had the ability to improve many of mouth and eye functions.

In this experimental study, the analysis of mean values before and after the treatment program by Aesthiometer showed that, there was a significant difference between the two groups with the best results for GII, this means that NMES 18 Hz, 30% intensity and 15 min duration gave the best results in IO nerve lesion following orbitozygomatic fractures.

Our findings of this experimental study are closely agreement and supported by the findings of Shiau *et al.* (1995) who applied NMES with different frequencies 10Hz, 20Hz and 30 Hz on 30 IO patients. They were divided into 3 equal groups accord to degree of orofacial disabilities. The treatment program was applied for 2 months, 3 sessions per week, 30% intensities and 20 min in duration. GI was treated by 10 Hz, GII by 20 Hz and GIII by 30Hz. finally the results showed that there were moderate significant differences in GII, mild improvements in GI and no improvements in GI.

The statistical findings of this work were supported bySchultze *et al.* (1999) when they conducted a case report on female traumatic IO nerve lesion. She has suffered from supraorbital and infraorbital sensory dysesthesia. The orofacial training for this patient required a continuous help from the therapist to assist the patient on pain control and improve Orofacial function. She received an additional therapy by NMES 18 Hz, 3 times per week, 20 min for 6 weeks. Her Orofacial ability was assessed every two weeks. At the end of the second week she required only an intermittent help instead of a firm continuous support. After four weeks, She required a minimal help and after the six weeks she required only a verbal support and the patient was able to do all Orofacial functions independently (McGimpey *et al.,* 2000).

Also, the results of this work are accepted by the work ofCoulson *et al.* (2006) when they applied NMES 20 Hz on 9 traumatic SO and IO nerve lesions and assessed sensory changes by disk criminator. The treatment program was applied for 10 weeks. The results showed that there was an improvement in ADL activities. These results are supported when they examined the beneficial effects of NMES 24 Hz on 5 male patients suffering from traumatic SO&IO. The main problems of patients were pain. They were treated for 8 weeks, day after day. Their statistics revealed that there were significant improvement in pain control.

In our work, there is improvement in two point discimination in both groups with the best results for NMES group. This coincides with the work of who applied NMES 25Hz on 27 post traumatic IO patients suffering from limited mechanical detection sensation threshold (two point discrimination) as measured by disk criminators. They were divided into two equal groups, GI was a control group treated by traditional physical therapy program while GII was an experimental group which received the same exercise program and NMES 25 Hz for 2 months, each session 20 min, day after day. After the treatment program, there was significant differences in NMES group as compared to non NMES group (Benoliel *et al.,* 2002).

Finally, in this experimental study the analysis of mean values before and after the treatment by NMES showed that there were significant differences within the two groups with the best results of GII. These results mean that NMES 20 Hz, 50% intensity and 15 min duration have given the best results according to Aesthesiometer, monofilaments, dental bud and pain scale. This prognosis may be a result of optimal application of NMES technique, suitable frequency, appropriate intensity and optimum duration.

Summary:

The purpose of the study was designed to clarify the modern trends of neurosensory rehabilitation in treatment of infraorbital nerve changes following zygomatic fractures. In this respect, neurosensory function was assessed with calibrated nylon monofilaments, electrical stimulation, heat detection thresholds and response to pin prick in the infraorbital, supraorbital and mental nerve regions in both sexes. Subjects, thirty males and females were the same degree of fractures severity according to Henderson's classification (grade1, 2& 3), their age ranged from 25-45years old and their weight ranged from 60-88Kg.They were randomly divided into two equal groups (G1and G2). G1, consists of 15 patients of both sexes and was treated by surgical procedures (reduction and fixation) and G2 consists of 15 patients was treated by the same surgical procedures and electrical neuromuscular stimulation with exercises therapy program. Vital signs as blood pressure, body temperature, pulse rate and respiratory rate measured before and after the treatment sessions. Assessments, visual analogue scale was used to measure degree of pain, Semmes-Weinstein monofilaments was used to

measure the light touch sensation, Aesthesiometer 2 point calliper was used to measure the two point discrimination sensation, Peltier probe was used to measure heat detection sensation. Moreover, by the use an ascending test of phyaction guidance-c system to measure the electrical detection threshold. Statistically the results for all groups were analyzed by t-test to compare the differences between the two groups. The statistical package of social sciences used for data processing using the p-value 0.05 as a level of significance. Results, showed that there were significant improvements in all variables in both groups in a favour to G2. Therefore, we concluded that, the use of surgical procedures combined with neuromuscular electrical stimulation and exercises program were the good method and open a new link to improve the recovery of infraorbital nerve sensory changes following zygomatic fractures.

Recommendations:

With the limitation of this study and from the obtained statistical results further investigations and research studies are recommended as further studies should be attempted to describe the effect of NMES on speech, cognition and facial expression with different frequencies and intensities of stimulation to treat many different disabilities in different neurological diseases.

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