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## RESEARCH ARTICLE

# INCIDENCE AND EVALUATION OF RECOVERY OF NEUROSENSORY CHANGES IN INFRAORBITAL NERVE FOLLOWING ZYGOMATIC COMPLEX FRACTURE

***Sanika Kulkarni, Parkar, M.I., Kumar Nilesh and Ashish Mahamuni**

Department of Oral and Maxillofacial Surgery, School of Dental Sciences, KIMSDU, Karad, India

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**ABSTRACT**

**Objective**: To evaluate the incidence of neurosensory changes in infraorbital nerve follwoing zygomaticomaxillary complex (ZMC) fractures post-trauma and to evaluate the recovery of neurosensory function subsequent to treatment of ZMC fractures over period of six months. **Materials and Method**: Twenty five patients with unilateral ZMC fracture were included in the study. Neurosensory function was assessed on affected side in the area of distribution of infraorbital nerve post trauma (pre-operatively) and at 1 week,1 month, 3 months and 6 months post-operatively with Pin Prick Test, Two Point Discrimination Test, Brush Stroke Directional Test, Warm and Cold Test and compared with that on the unaffected side, serving as the control. **Results:** It was found that neurosensory changes were seen in all the patients with ZMC fractures. The neurosensory recovery occurred within 3 to 6 months in almost all cases. Open reduction and internal skeletal fixation of ZMC fractures accelerated the neurosensory recovery. **Conclusion:** The present study showed that the neurosensory deficit was present in all cases of ZMC fractures. The study also revealed that Two Point Discrimination Test and Brush Stroke Direction Test were more reliable in terms of assessment of neurosensory deficits compared to other tests. The lateral side of nose showed late recovery among all other anatomical sites.



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## INTRODUCTION

The incidence of maxillofacial fractures has been increasing over the past decade as a result of increasing numbers of road traffic accidents and physical assaults (Fonseca and Walker, 1991). Fractures of the midface, mainly those of Zygomaticomaxillary Complex (ZMC), comprise of up to 15% of all facial bone fractures. The high incidence of these fractures probably relates to prominent position of zygoma within the facial skeleton, which frequently exposes it to traumatic forces. The incidence, cause, age, and sex predilection of zygomatic injuries vary, depending largely on the social, economic, political, and educational status of the population studied (Shetty *et al.,* 2015). The Infraorbital Nerve (ION) supplies the skin and mucous membranes of the middle portion of the face. This nerve is vulnerable to injury during surgical procedures of ZMC fractures involving infraorbital rim and midface fractures. The ION produces three main branches, the inferior palpebral, external nasal and superior labial (Shetty *et al.,* 2015). In most cases fracture lines involve the infraorbital foramen, canal, or fissure. Therefore, fractures of the ZMC are characterized by sensory neuropathy (specifically hypoesthesia) in the area of innervations of the ION, both as a presenting symptom, and as a postoperative complication (Kumar *et al.,* 2012). The regenerative capacity of ION is a controversial topic in the literature. The recovery rate of sensation depends on several factors, including the nature of injury to the nerve, the time between the injury and surgical intervention and method of treatment. In this study, the assessment of neurosensory function was done by both subjective and objective methods. The Pin Prick Test is done to evaluate the pin pressure nociception. The Two Point Discrimination is a test of tactilogenesis that assesses the quantity and density of functional sensory receptors and afferent fibers. The Brush Direction Stroke Test is a test for proprioception and assesses the integrity of the large A-α and A-β myelinated axons. Thermal Discrimination Test was done by Warm Test and Cold Test as useful adjunctive tests for determination of small diameter myelinated fibers and unmyelinated fibers (Lundborg, 1987).

***Corresponding author:*** **Sanika Kulkarni,**
Department of Oral and Maxillofacial Surgery, School of Dental Sciences, KIMSDU, Karad, India.

## MATERIALS AND METHODS

The present study was undertaken in the Department of Oral and Maxillofacial Surgery, School of Dental Sciences; KIMSU, Karad, after due approval of the Institutional Ethics Committee. Cases diagnosed with ZMC fractures reporting to the Department, from 1st Dec 2015 until 31st May 2017 were studied.

**Inclusion Criteria**

1. Patients of the age group of 18 to 50 years of both the genders
2. Patients with unilateral ZMC fractures
3. Patients willing to participate in the study and prepared for follow up visits

**Exclusion Criteria**

1. Patients with history of previous trauma to face and neurological abnormality of any kind.
2. Patients with medical disorders like Diabetes Mellitus
3. Patients with multiple bone fractures.
4. Patients with bilateral ZMC fracture

The patients were examined for facial skeleton bilaterally, with the non- traumatized side serving as a control after informed consent. Detailed history was recorded and physical examination of the patient was carried out. Preoperative radiographic examination was done using CT scan with 3D reconstruction. The following tests were performed to evaluate the neurosensory changes ; Pin Prick Test (PPT), Two Point Discrimination Test (TPT), Warm Test (WT), Cold Test (CT), Brush Directional Test (BDT). These tests were carried out on the affected side (Study Side) (SS) as well as on unaffected side (Control Side) (CS) of face. The areas which were tested bilaterally for ION disturbance were skin of lower eyelid, skin of anterior cheek, skin of lateral side of the nose, skin of upper lip, labial mucosa of upper lip (only by PPT). The above tests were carried out pre-operatively (post trauma) and post operatively after 1 week, 1 month, 3 months and 6 months.

**Pin Prick Test**

The device used to perform this test was a 22 Gauge hypodermic needle held between the thumb and index finger. It was applied firmly in a quick pricking fashion. A sufficient intensity of application should draw a small drop of blood at the puncture site. The test was carried out at all designated anatomically significant locations pre-operatively as well as at the end of one week, one month, three months and six months on both the sides. It was the only test which was carried out over the labial mucosa of upper lip. The criterion for interpretation of this test was based on Visual Analogue Scale (VAS) which includes 0 for no pain and 10 for worst pain.The patient was asked to grade the pain according to VAS, felt on both sides at every site at every time (Fig.1).

**Two Point Discrimination Test**

A sharp divider was used to measure Two Point Discrimination Test. The test was conducted by beginning with the points closed and progressively opening them in 1 mm increments until the patients could interpret the two points. This distance was recorded. Care was taken to ensure that the points touched the cutaneous receptors at the same time. The criterion for interpretation of this test was YES or NO (Fig.2).

**Warm Test**

In Warm Test a small glass tube containing water at $45^0$C was used. The patients were asked to indicate whether they felt a warm sensation or merely a touch which was compared with control side. The criterion for interpretation of this test was YES or NO (Fig.3).

**Cold Test**

The cold test was carried out with disposable plastic 2 ml syringe containing ice (temperature $0^o$C). The patients were asked to indicate whether they felt cold sensation or merely a touch which was compared with control side. The criterion for interpretation of this test was YES or NO (Fig.4).

**Brush Directional Test**

The instruments used in this test was Camlin Hairbrush (00). This brush was applied in a 1 cm stroke three times in each zone. The examiner randomly decided to move the stroke from right to left or left to right at each interval. An appropriate response was considered an accurate indication of the direction the brush which was also compared with control side. The criterion for interpretation of this test was also YES or NO (Fig.5).

**Statistical Analysis**

For all the tests at every site, descriptive statistics were expressed as mean ± Standard Deviation. The change in mean scores of all the tests over a period of 6 months was analyzed using repeated measures ANOVA Test. The change in mean scores over a period of 6 months was analyzed using repeated measures ANOVA Test followed by Bonferroni Post hoc Test for comparison of intervals of time period. Comparison of two groups (SS Vs CS) for scores of Two Point Discrimination Test, Warm Test, Cold Test and Brush Stroke Test over a period of time was done with Mann Whitney 'U' Test.

**Fig. 1: Pin Prick Test at various anatomical sites: a-upper labial mucosa, b-skin of anterior cheek, c-skin of infraorbital region, d-skin of lateral side of nose, e- skin of upper lip**

**Fig. 2. Two Point Discrimination Test at various anatomical sites: a-skin of infraorbital region, b-skin of anterior cheek, c- skin of lateral side of nose, d-skin of upper lip**

**Fig. 3. Warm Test at various anatomical sites: a-skin of infraorbital region, b-skin of anterior cheek, c- skin of lateral side of nose, d-skin of upper lip**

**Fig. 4. Cold Test at various anatomical sites: a-skin of infraorbital region, b- skin of lateral side of nose, c- skin of anterior cheek, d-skin of upper lip**

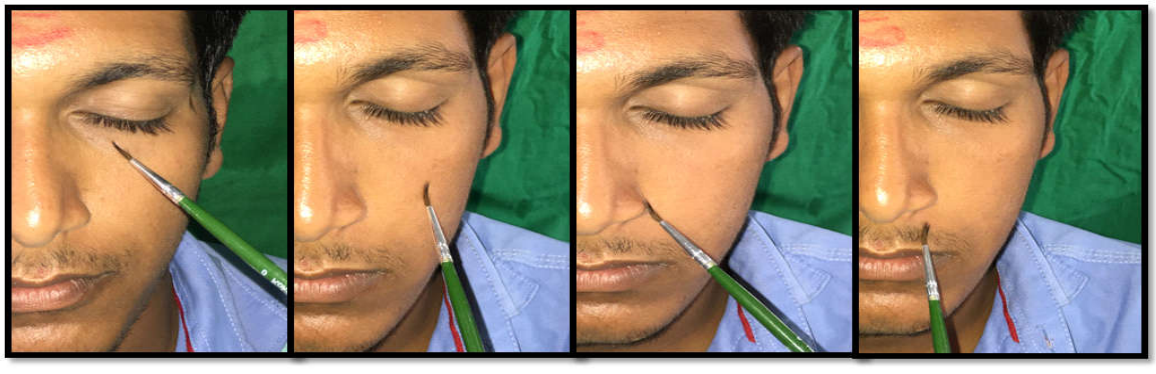

**Fig. 5. Brush Direction Test at various anatomical sites: a-skin of infraorbital region, b-skin of anterior cheek, c- skin of lateral side of nose, d-skin of upper lip**

## RESULTS

For Pin Prick Test at various regions over a period of time results were statistically significant at all intervals (Tables 1, 2). The Frequency Distribution and Percentage of Reponses (Yes/No) for various tests over period of time at all the sites showed almost 100% recoveries at the end of 6 months except at lateral side of nose (Table 3, 4). Comparison of Study Side and Control Side for Two Point Discrimination Test, Warm Test, Cold Test and Brush Stroke Test over a period of time at various regions showed statistically significant difference almost at the end of 3 months (Table 5).

In this clinical study, 25 patients with unilateral ZMC fractures were assessed for the neurosensory alterations. The results revealed the ION sensory disturbances occurred in all 25 (100%) patients. Our patients mainly exhibited hypoalgesic responses consistent with nerve damage. The neurosensory disturbances resolved within the first 3 to 6 months post-operatively. In this study, all the tests at all the anatomical sites showed 100% recovery in all the cases except for the Cold Test at lateral side of nose which was not totally recovered in two case (8%) at the end of 6 months post-operatively. Approximately10 (73.3%) cases showed total recovery within 3 months post operatively and 14 (93.3%) cases in 6 months post-operatively.

**Table 1. Repeated Measures ANOVA for comparison of Pin Prick Test scores at various regions over a period of time**

| | | Lower Eye Lid Region (Mean ± SD) | Anterior Cheek (Mean ± SD) | Lateral Side of Nose (Mean ± SD) | Upper Lip (Mean ± SD) | Labial Mucosa (Mean ± SD) |
|---|---|---|---|---|---|---|
| Pin Prick Test (n=25) | Baseline | 3.48 ±1.53 | 3.20 ±1.19 | 2.92 ±1.32 | 3.20 ±1.29 | 3.68 ±1.10 |
| | 1 Week | 3.24 ± 1.48 | 3.08 ± 1.03 | 2.80 ± 1.08 | 3.44 ± 1.15 | 3.84 ± .94 |
| | 1 Month | 4.24 ± 1.20 | 4.08 ± 1.11 | 3.76 ± 1.05 | 4.08 ± 0.90 | 4.48 ± .71 |
| | 3 Months | 4.44 ± 1.19 | 4.20 ± 1.11 | 4.20 ± .91 | 4.24 ± .87 | 4.80 ± .40 |
| | 6 Months | 4.64 ± .90 | 4.60 ± .70 | 4.52 ± .71 | 4.84 ± .37 | 4.88 ± .33 |
| p value (Repeated Measures ANOVA) | | <0.001 | <0.001 | <0.001 | <0.001 | 0.001 |

**Table 2. Comparison of Pin prick Test Scores in the two groups (Control Side vs. Study Side) for various time intervals at various regions**

| SS vs CS | Lower Eye Lid Region | Anterior Cheek | Lateral Side of Nose | Upper Lip | Labial Mucosa |
|---|---|---|---|---|---|
| Baseline | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| 1 Week | <0.001 | <0.001 | <0.001 | <0.001 | <0.001 |
| 1 Month | 0.021 | 0.002 | <0.001 | <0.001 | 0.030 |
| 3 Months | 0.116 | 0.0090 | 0.002 | 0.003 | 0.720 |
| 6 Months | 0.313 | 0.140 | 0.053 | 1.000 | 0.691 |

**Table 3. Frequency Distribution of Reponses (Yes/No) for various tests over a period of time at lower eyelid region**

| | Pre op | | 1 Week | | 1 Month | | 3 Months | | 6 Months | |
|---|---|---|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | n | % | N | % |
| **Two Point Discrimination Test** | | | | | | | | | | |
| NO | 22 | 88.0 | 22 | 88.0 | 8 | 32.0 | 2 | 8.0 | 0 | 0 |
| YES | 3 | 12.0 | 3 | 12.0 | 17 | 68.0 | 23 | 92.0 | 25 | 100.0 |
| **Warm Test** | | | | | | | | | | |
| NO | 18 | 72.0 | 19 | 76.0 | 9 | 36.0 | 1 | 4.0 | 0 | 0 |
| YES | 7 | 28.0 | 6 | 24.0 | 16 | 64.0 | 24 | 96.0 | 25 | 100.0 |
| Cold Test | | | | | | | | | | |
| NO | 16 | 64.0 | 16 | 64.0 | 7 | 28.0 | 2 | 8.0 | 0 | 0 |
| YES | 9 | 36.0 | 9 | 36.0 | 18 | 72.0 | 23 | 92.0 | 25 | 100.0 |
| **Brush Direction Test** | | | | | | | | | | |
| NO | 16 | 64.0 | 12 | 48.0 | 5 | 20.0 | 0 | 0 | 0 | 0 |
| YES | 9 | 36.0 | 13 | 52.0 | 20 | 80.0 | 25 | 100.0 | 25 | 100.0 |

**Table 4. Frequency Distribution of Reponses (Yes/No) for various Tests over period of time at Anterior cheek region**

| | Pre op | | 1 Week | | 1 month | | 3 Months | | 6 Months | |
|---|---|---|---|---|---|---|---|---|---|---|
| TPT | n | % | n | % | n | % | n | % | n | % |
| **Two Point Discrimination Test** | | | | | | | | | | |
| NO | 08 | 32.0 | 08 | 32.0 | 3 | 12.0 | 1 | 4 | 0 | 0 |
| YES | 17 | 68.0 | 17 | 68.0 | 22 | 88.00 | 24 | 96.0 | 25 | 100.0 |
| **Warm Test** | | | | | | | | | | |
| NO | 12 | 48.0 | 12 | 48.0 | 2 | 8.0 | 1 | 4.0 | 0 | 0 |
| YES | 13 | 52.0 | 13 | 52.0 | 23 | 92.0 | 24 | 96.0 | 25 | 100.0 |
| **Cold Test** | | | | | | | | | | |
| NO | 7 | 28.0 | 7 | 28.0 | 2 | 8.0 | 0 | 0 | 0 | 0 |
| YES | 18 | 72.0 | 18 | 72.0 | 23 | 92.0 | 25 | 100.0 | 25 | 100.0 |
| **Brush Direction Test** | | | | | | | | | | |
| NO | 6 | 24.0 | 5 | 20.0 | 1 | 4.0 | 0 | 0 | 0 | 0 |
| YES | 19 | 76.0 | 20 | 80.0 | 24 | 96.0 | 25 | 100.0 | 25 | 100.0 |

**Table 5 Frequency Distribution and Percentage of Reponses (YES/NO ) for various tests over a period of time at Lateral side of nose region**

| | Pre op | | 1 Week | | 1 Month | | 3 Months | | 6 Months | |
|---|---|---|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | n | % | N | % |
| **Two Point Discrimination Test** | | | | | | | | | | |
| NO | 13 | 52.0 | 11 | 44.0 | 4 | 16.0 | 0 | 0 | 0 | 0 |
| YES | 12 | 48.0 | 14 | 56.0 | 21 | 84.0 | 25 | 100.0 | 25 | 100.0 |
| **Warm Test** | | | | | | | | | | |
| NO | 16 | 64.0 | 16 | 64.0 | 5 | 20.0 | 4 | 16.0 | 0 | 0 |
| YES | 9 | 36.0 | 9 | 36.0 | 20 | 80.0 | 21 | 84.0 | 25 | 100.0 |
| **Cold Test** | | | | | | | | | | |
| NO | 12 | 48.0 | 10 | 40.0 | 2 | 8.0 | 0 | 0 | 0 | 0 |
| YES | 13 | 52.0 | 15 | 60.0 | 23 | 92.0 | 25 | 100.0 | 25 | 100.0 |
| **Brush Direction Test** | | | | | | | | | | |
| NO | 7 | 28.0 | 7 | 28.0 | 3 | 12.0 | 1 | 4.0 | 0 | 0 |
| YES | 18 | 72.0 | 18 | 72.0 | 22 | 88.0 | 24 | 96.0 | 25 | 100.0 |

**Table 6 .Frequency distribution of responses (YES/NO) for various tests over a period of time at upper lip region**

| | Pre op | | 1 Week | | 1 Month | | 3 Months | | 6 Months | |
|---|---|---|---|---|---|---|---|---|---|---|
| TPT | n | % | n | % | n | % | n | % | N | % |
| **Two Point Discrimination Test** | | | | | | | | | | |
| NO | 23 | 92.0 | 22 | 88.0 | 6 | 24.0 | 2 | 8.0 | 0 | 0 |
| YES | 2 | 8.0 | 3 | 12.0 | 19 | 76.0 | 23 | 92.0 | 25 | 100.0 |
| **Warm Test** | | | | | | | | | | |
| NO | 17 | 68.0 | 15 | 60.0 | 6 | 24.0 | 6 | 24.0 | 0 | 0 |
| YES | 8 | 32.0 | 10 | 40.0 | 19 | 76.0 | 19 | 76.0 | 25 | 100.0 |
| **Cold Test** | | | | | | | | | | |
| NO | 18 | 72.0 | 17 | 68.0 | 5 | 20.0 | 4 | 16.0 | 2 | 8.0 |
| YES | 7 | 28.0 | 8 | 32.0 | 20 | 80.0 | 21 | 84.0 | 23 | 92.0 |
| **Brush Direction Test** | | | | | | | | | | |
| NO | 9 | 36.0 | 7 | 28.0 | 4 | 16.0 | 0 | 0 | 0 | 0 |
| YES | 16 | 64.0 | 18 | 72.0 | 21 | 84.0 | 25 | 100.0 | 25 | 100.0 |

**Table 7. Comparison of other tests scores in the two Groups (Control Side vs. Study Site) for various time of intervals at various regions**

| SS vs CS (N =25) | Lower Eye Lid Region | Anterior Cheek | Lateral Side of Nose | Upper Lip |
|---|---|---|---|---|
| **Two Point Discrimination Test** | | | | |
| Baseline | 0.002 | <0.001 | <0.001 | <0.001 |
| 1 Week | 0.002 | <0.001 | <0.001 | <0.001 |
| 1 Month | 0.077 | 0.002 | 0.010 | 0.039 |
| 3 Months | 0.317 | 0.153 | 0.153 | 1.000 |
| 6 Months | 1.000 | 1.000 | 1.000 | 1.000 |
| **Warm Test** | | | | |
| Baseline | <0.001 | <0.001 | <0.001 | <0.001 |
| 1 Week | <0.001 | <0.001 | <0.001 | <0.001 |
| 1 Month | 0.153 | 0.001 | 0.010 | 0.020 |
| 3 Months | 0.317 | 0.317 | 0.010 | 0.039 |
| 6 Months | 1.000 | 1.000 | 1.000 | 1.000 |
| **Cold Test** | | | | |
| Baseline | 0.005 | <0.001 | <0.001 | <0.001 |
| 1 Week | 0.005 | <0.001 | <0.001 | <0.001 |
| 1 Month | 0.153 | 0.005 | 0.020 | 0.153 |
| 3 Months | 1.000 | 0.153 | 0.039 | 1.000 |
| 6 Months | 1.000 | 1.000 | 0.153 | 1.000 |
| **Brush Direction Test** | | | | |
| Baseline | 0.010 | <0.001 | 0.001 | 0.005 |
| 1 Week | 0.020 | <0.001 | 0.005 | 0.005 |
| 1 Month | 0.317 | 0.020 | 0.039 | 0.077 |
| 3 Months | 1.000 | 1.000 | 1.000 | 0.317 |
| 6 Months | 1.000 | 1.000 | 1.000 | 1.000 |

## DISCUSSION

Our patients mainly exhibited hypoalgesic responses consistent with nerve damage. The nature of the nerve injury in zygomatic fractures is, however, unclear and may involve traction, pressure, ischemia, inflammation, and physical damage. Not all nerve fibers have the same susceptibility for compression injuries and ischemia. The A–β fibers responsible for mechanoception (touch) are more susceptible to compression and ischemia than the A-δ (myelinated) and C (unmyelinated) fibers (Sakavicius *et al.,* 2008). Preoperative and 1 week postoperative response to Two Point Discrimnation and Brush Stroke Direction Tests revealed that there was significant improvement in neurosensory distribution 1 week after the surgical procedure and after that the improvement was slow till 6 months. Similarly for Warm and Cold Tests, significant improvement was seen 1 month postoperatively. On the basis of these results we can conclude that mechanoceptive tests gave early recovery results as compared to nociceptive tests which assess the specific receptors and axons. For Pin

Prick Test also the statistically significant values were present after comparing pre-operative and 6 month post-operative values. For Pin Prick Test labial mucosas of upper lip showed earliest recovery followed by skin of lower eyelid, skin of upper lip, skin of anterior cheek and lastly lateral sides of the nose. In case of other tests except for Brush Direction Test, skin of upper lip showed earliest recovery followed by skin of lower eyelid and cheek. Overall, skin of lateral side of nose showed late recovery in all the tests. Sakavicius and Juodzbalys (2008) (Ghali and Epker, 1989) carried out a study on a total of 478 patients with unilateral ZMC fractures. ION sensory disturbances were diagnosed in 308 (64.4%) patients. Injury of the ION was expressed as Asymmetry Index, which was calculated as a ratio of percentages between the affected side and the intact side. Electric pain detection thresholds at the innervations of skin before treatment and 14 days, 1, 3, 6 and 12 months postoperatively. 57 (11.9%) of the patients were diagnosed with hyperalgesia and for 251 (52.5%) patients with hypoalgesia. As a result of retrospective analysis, ION sensory disturbances and its functional recovery, ION injury severity was classified as mild, moderate and severe. It was found that the dynamics and outcome of the functional ION recovery depended on the severity of the injury and the presence of infraorbital canal damage. Function was completely recovered within 3 months after treatment in cases with mild nerve injury. In moderate cases, complete recovery was seen within 6 months and in 106 (34.6%) severe cases, within a 12-month period after treatment. Ahmed et al (2009) studied those patients who presented with clinical findings of unilateral ZMC fractures. This study revealed that neurosensory alteration after ZMC fractures was common. The authors stated that there was direct correlation between the recovery of paresthesia and reduction of fracture. The mild neurosensory disturbance was more likely to resolve within shorter time period than the severe one (Benoliel *et al.,* 2005) A severe neurosensory deficit does not imply a permanent long term deficit even with the implied second or third degree nerve injury (Akal *et al.,* 2000).

**Conclusion**

The clinical sensory tests like Pin Prick Test, Two Point Discrimination Test, Warm Test, Cold Test and Brush Stroke Direction Test are effective guide to determine the kind of nerve fibers which have undergone injury. The neurosensory recovery occurs within 3 to 6 months in almost all cases. The incidence of residual sensory dysfunction varied with the testing modality.

According to this study the Two Point Discrimination Test and Brush Stroke Direction Test were more reliable in terms of assessment of neurosensory deficits compared to other tests. Considering the anatomical site; the lateral side of nose showed late recovery among all other anatomical sites. It can be concluded that the incidence of neurosensory changes in ION is one of the reason for operative management of ZMC fractures. The recovery is seen in all except in two cases within 6 months post-operative period after open reduction and internal fixation. The reason behind this may be extensive injury to the nerve.

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