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Original Article

Diagnostic properties of sensitivity changes in patients with maxillofacial fractures: a systematic review

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Aim: Verify the accuracy of objective assessments compared to subjective tests in detecting changes in somatosensory perception in individuals affected by maxillofacial trauma. **Methods:** The review (PROSPERO n ° CRD42019125546) used the databases: MEDLINE, Cochrane, EMBASE, LILACS and other bibliographic resources. Prospective and retrospective studies that used objective and subjective methods of assessing facial sensitivity in maxillofacial fractures were included. There was no restriction on language or publication date. Risk of bias was assessed using the QUADAS-2. Data extraction and analysis were performed using a form developed for the study. **Results:** 21 studies were included. The clinical objective examination mainly includes assessments of: tactile sensitivity (95.24%) and nociceptive sensitivity (57.14%).The subjective assessment was based on the patient's report, spontaneously (61.90%), guided by structured questionnaires (33.33%) and/or using scales (9.52%) to measure the degree of impairment. In risk of bias assessment, were observed no adequate interpretation and classification of changes in subjective sensitivity, subject to inappropriate analysis of the data. In addition, the studies bring several instruments without standardization for assessing sensory modalities. **Conclusion:** The objective assessment is a complement to the subjective assessment, using the touch assessment as the main parameter in the profile of the facial peripheral integrity, associated or not with nociceptive assessment. Lack of consensus on the indication of specific instruments for testing is a limiting factor. Thus, based on the studies, is proposed a minimum battery of sensitivity assessment to obtain an overview of the patient's peripheral nervous situation.

KEYWORDS: Facial injuries. Zygomatic fractures. Jaw fracture. Somatosensory disorders. Sensation disorders. Systematic reviews as topic.

Introduction

Trauma involving the skull and face are among the leading causes of morbidity and mortality, especially in the young population[1]. It is estimated that, globally, there are 7.5 million new cases of facial fractures with 1.8 million people living with their comorbidities[2]. With occurrence in more significant numbers in male individuals, injuries are the result of traffic accidents, falls, physical violence, assaults, occupational, and sports accidents[1,3]. In general, besides bone fractures, individuals have other injuries that can limit their functional capacity[3].

Among these traumas, maxillofacial traumas, as well as their repair procedures, cause bone dislocations that can result in lesions in the peripheral nerve, which are responsible for facial sensation and perception. Thus, compression, sectioning, or stretching of the branches of the trigeminal nerve (V1, V2, and V3) and the nerves of the cervical plexus (C1 and C2)[4] may result in somatosensory changes that impact functionality, quality of life, and well-being of individuals. It may impair the functions of chewing, breathing, swallowing, sucking, and speaking[5]. The diagnosis of these changes is based on clinical and instrumental assessment, which considers the patient's report, the use of subjective questionnaires and quantitative neurosensory tests[5,6].

Subjective verification based on the symptom referred by the patient is the gold standard to determine the diagnosis, as it considers aspects of somatosensory perception more comprehensively. In it, individuals are submitted to a qualitative assessment of changes in sensory perception[5,6]. It considers parameters such as the presence or absence of change and the description of the change sensation[5].

The objective assessment of sensory changes, represented by quantitative tests, is based into parameters that assess the patient's perception according to the different somatosensory modalities explored. It determines the profile of the detection of thermal, painful, touch, and proprioceptive stimuli, using instruments to identify perception and quantitative measurement of perceptual thresholds[6]. The objective assessment of facial sensitivity uses different techniques. They can be classified according to the type of fiber being stimulated. It may be associated with Aβ fibers, myelinated (through tests involving touch sensation) or myelinated A δ fibers and C fibers, not myelinated (by verifying thermal and nociceptive sensation)[6].

Thus, the present study aims to conduct a systematic review of the literature to verify the accuracy of objective tests compared to subjective tests of facial sensitivity in detecting changes in somatosensory perception in individuals affected by maxillofacial trauma.

Materials and methods

This review was conducted based on the guidelines proposed by the Cochrane Handbook for Systematic Reviews of Diagnostic Test Accuracy reported follow-

ing the PRISMA[7] recommendations and registered in PROSPERO under number CRD42019125546. Studies that used objective and subjective methods of assessing facial sensitivity in patients with maxillofacial trauma were included.

Criteria for including studies in this review

Types of studies

Studies that used objective and subjective methods to assess facial sensitivity to detect peripheral somatosensory changes resulting from maxillofacial trauma were included. Prospective and retrospective studies were considered, provided they had both exams.

Participants

Studies with an assessment of patients with sensory changes in the peripheral nervous system originating from trauma or postoperative traumatic maxillofacial injuries. Participants underwent at least one of the modalities of objective assessment and at least one modality of subjective sensitivity assessment.

Index test

Changes in facial sensitivity must have been assessed objectively using quantitative tests or scales.

Reference standard

All patients must have been subjected to a subjective assessment of changes in sensory perception considering the following parameters: presence or absence of change or description of the sensation.

Target conditions

Changes in the peripheral sensory perception of the face.

Search methods for study identification

The search was carried out in the MEDLINE, Cochrane, EMBASE, Scopus, and LILACS databases of articles published until March 2019, using the following terms and their correlates: "facial fractures," "zygomatic-orbital fracture," "mandibular fractures," and "somatosensory disorders." The search strategy for each database is available in Appendix 1. The search was complemented by the manual review of other bibliographic resources in the health field, such as Google Scholar, OpenGrey, ProQuest, dissertations, theses, and reference lists. There was no restriction on language or publication date. The authors of the selected studies were contacted to request missing or insufficient data.

Data collection and analysis

Selection of studies

The studies were initially analyzed by title and abstracts by two independent evaluators (KWS and ECR), including studies that met the eligibility criteria. A third evaluator (DCGMV) judged doubts regarding the inclusion to obtain consensus. Those eligible in this stage were read in full for a final decision on their inclusion. Those selected were registered on a form regarding inclusion or exclusion in the study at each step of the selection process, as well as the respective reasons.

Data extraction and management

The data from the included studies were extracted into a form developed specifically for this analysis. First, data on the characteristics of the studies and their population were tabulated. Data were also extracted regarding the objective and subjective assessment methods used, as well as a description of the facial sensitivity assessment techniques performed.

Assessment of methodological quality

The studies were assessed regarding quality using the Quality Assessment Tool for Diagnostic Accuracy Studies (QUADAS-2)[8] by two independent evaluators (KWS and ECR) and, in case of disagreement, a third evaluator (DCGMV) was consulted. Divided into four domains (patient selection, index test, reference standard, and flow and timing) the QUADAS-2 tool analyzes the methodological quality of the included studies, judging the risk of bias and applicability[8].

RESULTS

Study selection

Out of the 7782 titles and abstracts analyzed from the search strategies, 135 met the eligibility criteria for reading the full manuscript. The authors of four articles[9-12] were contacted for more information on the methodology used in their studies, but they were excluded due to a lack of responses. Thus, for quality analysis, 21 studies[13-33] were included. The PRISMA flow diagram (Figure 1) provides, according to the different phases of the systematic review, the registration of the identified, included and excluded studies, and the reasons for the exclusions.

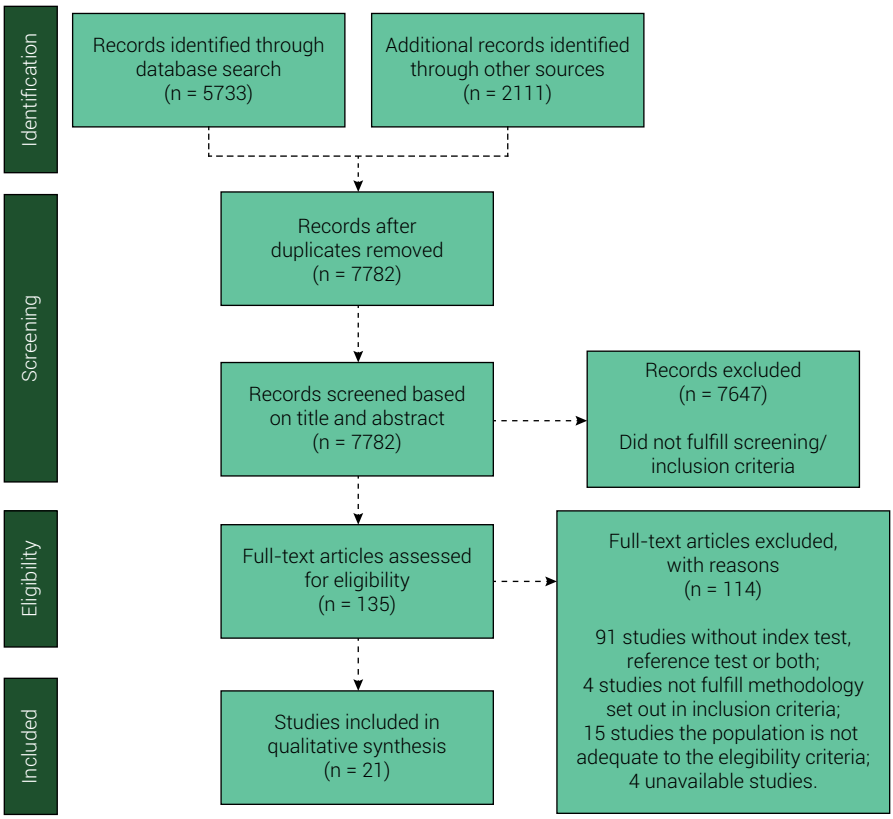

Figure 1. PRISMA flow diagram.

Study characteristics

The characteristics of the studies included are described in Table 1. The studies were predominantly observational (85.71%), with a sample composed of individuals aged between 11 and 83 years, mostly males. Individuals from 11 years old were included when they presented the same type of intervention used in adults[34]. Despite the literature citing specific facial sensitivity tests that show different according to the individual's age and sex[4], the studies included in this review do not show differences in results in the assessments regarding the age and sex variables.

Among the causes of trauma, from the most recurring to the least common are: traffic accidents, physical violence, assaults, falls, sports accidents, firearm injuries, work accidents, and domestic accidents. The most frequent type of fracture was the middle third of the face (52.38%), involving the regions of the zygoma, maxilla, and orbit; mandibular fractures (38.10%), including the regions of the body, angle, branch, symphysis, parasymphysis, head, and condylar process; and finally, bimaxillary (9.52%). Concerning surgical interventions, most of them had a rigid internal fixation with open reduction (76.19%), with intra-oral (37.5%), extra-oral (37.5%), or combined (25%) incisions. Some studies (9.52%) mention the use of maxillomandibular fixation to stabilize the fracture, and others also bring conservative treatment (14.28%) as an option for trauma management.

Table 1. Characteristics of the studies included

Author, Year	Country	Study Design	Age	n (F/M)	Cause of Trauma	Location of fracture	Maxilofacial Surgery	Surgical incision
Anchlia, 2018[13]	India	One-arm clinical trial	Average 30 years	20 (6/14)	Traffic accidents (61,1%) Interpersonal violence (38,8%)	Mandible fractures: - Body fractures (passing through the mental foramina)	ORIF	Intraoral vestibular incision
Neovius, 2017[14]	Sweden	Retrospective Cohort	ND	81 (16/65)	Traffic accidents (38%) Assaults (31%) Fall in (17%) Others (14%)	Isolated zygomatic fracture (57%) Isolated blow-out fracture (11%) Zygomatic fracture combined with a blow-out fracture and (5%) Bilateral or multiple fracture (27 %)	OR and/ or ORIF	Lower eyelid incision
Okochi, 2015[15]	Japan	Retrospective Cohort	25.0 ± 12.7	10 (4/6)	Fall in (50%) Sports accidents (30%) Traffic accidents (20%)	Unilateral zygomaticomaxillary complex fracture	ORIF	Lateral eyebrow, lower eyelid subciliary and intraoral approach
Scott, 2014[16]	UK	Retrospective Cohort	ND	150	ND	Body, angle and ramus (passing between the mandibular and mental foramen)	ORIF	Intraoral approach
Mayrink, 2012[17]	Brazil	Prospective Cohort	Average 27.74 (range 15 to 68)	19 (4/15)	Traffic accidents (78,94%) Fall (5,26%) Interpersonal violence (15,78%)	Symphysis, body, angle, ramus and condylar process, isolated or combined	ORIF	Extra-buccal, trans- and intrabuccal (in body and condyle fractures in the same patient)
Bagheri, 2009[18]	USA	Retrospective Cohort	Average 37.1 (range 11 to 61)	42 (17/ 25)	ND	Zygomaticomaxillary complex fracture, parasymphysis, angle, ramus and mandible body	ND	ND
Sakavicius, 2008[19]	Lithuania	Retrospective Cohort	Mean 32,17 (range 15 to 78)	478 (86/392)	Assaults (32,63%) Road traffic accidents (29,49%) Sports accidents (25,52%) Others (12,34%)	Unilateral zygomaticomaxillary complex fractures	Closed reduction or ORIF if displacement	Closed reduction or lower eyelid subciliary approach
Barry, 2007[20]	Ireland	Retrospective Cohort	Mean 22.4 (range 16 to 42)	50 (2/48)	Interpersonal violence (70%) Sporting injury (20%) Falls (8%) Motor vehicle accidents (2%)	Angle and ramus (47 were associated with an impacted or erupted third molar - teeth in the line of fracture)	ORIF with MMF if occlusal displacement	Extended third molar incision

Continue

Continuation

Iizuka, 1991[21]	Finland	Prospective Cohort	Mean 33.5 (range 16 to 83)	133 (25/108)	ND	Body, angle and ramus (passing between the mandibular canal)	ORIF	Extraoral (submandibular or retromandibular) and intraoral approach
Fogaça, 2004[22]	Brazil	Retrospective Cross-sectional	ND	25	ND	Unilateral zygoma fractures	ORIF	ND
Fayazi, 2013[23]	Germany	Prospective Cohort	41±7.3 (range 10 to 65 years)	49 (5/44)	Motor vehicle accident (75,5%) Sport events (10.2%) Interpersonal violence (10,2%) Falling (4,1%)	Parasymphysis, symphysis, condylar process and head, body, angle, ramus, coronoid process fractures	MMF	Erich arch bars
Siddiqui, 2007[24]	UK	Randomized controlled trial	Range 17 to 57	85 (10/75)	ND	Angle and ramus (comminuted fractures were excluded)	ORIF	At the external oblique ridge or transbuccal
McGimpsey, 2000[25]	UK	Cross-sectional	Range 11 to 80	45 (45M)	Assault (66,67%) Falls (15,55%) Traffic accidents (11,11%) Sports accidents (6,67%)	Zygomatic complex	Gillies elevation, Poswillo hook, a combination of both Gillies and Poswillo or conservative	Temporal (Gillies) approach
Vriens, 1998[26]	Netherlands	Prospective Cohort	33.2± 13.6 (range 14 to 77)	65	ND	Zygomaticomaxillary complex fracture and orbit (frontozygomatic suture or orbital blow out).	ORIF	Temporal (Gillies) approach
Kipper, 2016[27]	Brazil	Cross-sectional study	Above 18 years	14	ND	Zygoma and other fractures	ND	ND
Fogaça, 2008[28]	Brazil	Cross-sectional study	ND	25 (9/16)	ND	Zygoma and orbit	ORIF	ND
Kesarwani, 1989[29]	Canada	Retrospective Cohort	Mean 37 (range 18 to 57)	20 (4/16)	ND	Panfacial fractures, maxilla, orbit, nasoethmoid, zygoma and mandible	ORIF	Coronal flaps, subciliary, upper and lower buccal sulcus
Abd El-Kader, 2011[30]	Egypt	One-arm clinical trial	Mean 31 (range 20 to 42)	12 (2/10)	Traffic accidents (58,33%) Interpersonal violence (41,67%)	Zygomaticomaxillary complex fracture	ORIF	Subciliary, buccogingival and lateral eyebrow approaches

Continue

Continuation

Leonhardt, 2005[31]	Germany	Prospective Cohort	Mean 31 (ranged 15 to 70)	30	ND	Angle and ramus	ORIF	Intraoral
Marzola, 2006[32]	Brazil	Prospective Cohort	Range 11 to 51	100 (19/81)	Interpersonal violence (23%) Traffic accidents (37%) Domestic accidents (16%) Sports accidents (6%) Working accidents (4%) Others (14%)	Zygomaticomaxillary complex fracture	ORIF or conservative	ND
Ahmed, 2010[33]	India	Prospective Cohort	From 20 years	133 (3/130)	ND	Zygoma	ND	ND

Legend: ND: not described; ORIF: Open Reduction Internal Fixation; MMF: Maxillomandibular Fixation

Risk of bias

Figure 2 gathers the results of the quality analysis, which is described below.

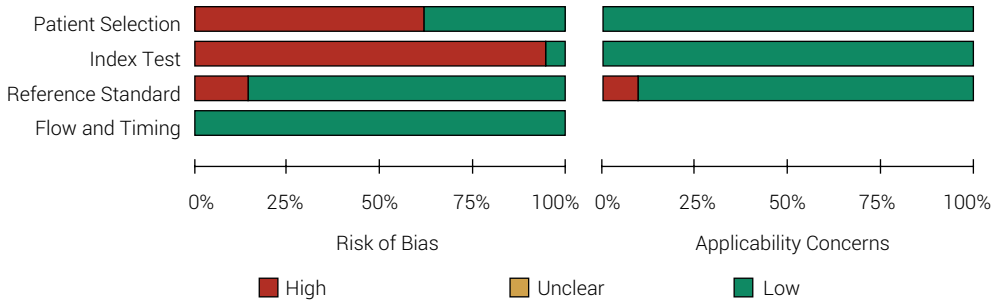

Figure 2. Methodological evaluation according to QUADAS-2 of the included studies.

Patient Selection

Thirteen (61.90%) studies[13-17,19,21,25-31] had a high risk of bias and 8 (38,10%) studies[17,18,20,22-24,32,33] had a low risk due to comparing individuals with changes to healthy individuals in case-control designs. As for applicability, all studies were considered adequate, since the patient profile were in accordance with the eligibility criteria listed for this review.

Index Test

As for the risk of bias concerning the objective sensitivity test, 20 (95.24%) studies[13-21,23-33] had high risk, and 1 (4.76%) study[22] had low risk. The high rate of bias was due to the lack of blinding to subjective assessment by the examiner to perform the objective tests. The non-independent assessment may have distorted the execution or interpretation of the objective test. Also, there was no adequate description of the interpretation of the tests, without description of diagnostic thresholds. As for applicability, all studies were considered adequate, as they contemplate the review proposal.

Reference Standard

3 (14.29%) studies[22,29,33] had high risk and 18 (85.71%) studies[13-21,23-27,29-32] low risk. It was considered a low-risk criterion when the reference test was conducted according to the patient's report, without adaptation of the terms by the researchers. As for applicability, 19 (90.48%) studies[13-21,23-32] showed good applicability, and 2 (9.52%) studies[22,33] showed flaws in their applicability. In one of the studies, there was an interpretation of the perceptual responses by the authors[33], which may distort the data obtained. In another, the assessment procedures were not adequately described for accurate classification[22].

Flow and timing

All studies were classified as having a low risk of bias, as it was considered that the application interval between the reference test and the index test is not a variable that can interfere with the test results. All patients in the studies were submitted to the index and reference tests and included in the data analysis.

Assessments

The characteristics of the facial sensitivity assessment are described in Table 2. The assessment moments involved periods of the preoperative period (4.76%), postoperative period (47.62%), and both (42.86%), and some had followed up to complete nervous recovery (4.76 %). The postoperative follow-up time varied, being performed in the period between the first week (42.86%), the first month (57.14%), the second month (14.28%), the third month (42.86%), the sixth month (42.86%), and the first year (52.38%). Some studies[14-16,29] extend the follow-up to more than one year (19.05%) after surgery.

Facial sensitivity assessments were performed to check the activity of the following nerve portions: infraorbital (61.90%), lower alveolar (38.10%), supraorbital (4.76%), lingual (4.76%), and buccal (4.76%). Thus, classifying the assessments from the main branch of the trigeminal nerve, it is observed: 61.90% ophthalmic branch, 42.86% mandibular branch, and 4.76% maxillary branch.

As for the assessed facial region, the assessment of the ophthalmic branch was performed on the upper lip (53.85%), cheeks (38.46%), nasal and paranasal region (46.15%), eyelids (23.08%), gingiva (7.69%), and forehead (7.69%). The activity of the maxillary branch was observed in the region of the cheeks (100%) and the assessments of the mandibular branch in the lower lip (80%), chin (40%), labial commissures (10%), and lower border of the mandible (10%).

When assessing Aβ type fibers, touch sensation (95.24%), the following methods were used: *light touch/static light touch* (59.09%), *two-point discrimination* (45.45%) - moving (20%) or static (60%), *mechanical detection threshold* (18.18%), *direction sensation* (13.63%), *moving-touch discrimination* (9.09%), *stimulus localization* (4.54%), vibratory sensation (4.54%), and *trigeminal somatosensory evoked potential* (4.54%).

As for Aδ and C fibers, thermal sensation (4.76%), painful (38.1%) or both (14.28%), the following measurements were used: *painful stimuli/pinprick* (75%), *pain detection threshold* (25%), *thermal sensation* (25%), and *thermal discrimination* (8.33%).

Table 2. Facial sensibility assessment

Author and year published	Moments of evaluation		Moments of evaluation – Follow up	Nerve assessed	Evaluation Region	Aβ fibers (touch)	Aδ fibers and C fibers (temperature and pain)	Subjective evaluation
	Preop.	Posop.						
Anchlia, 2018[13]	N	Y	1st, 4th and 12th weeks after surgery	IAN (V3)	Lower lip	Light touch, two-point discrimination	Pin prick	Questionnaire
Neovius, 2017[14]	N	Y	3 – 7.6 years	ION (V1)	Alar base and upper lip	Light touch, mechanical detection threshold	NE	Scale (0-100)
Okochi, 2015[15]	Y	Y	Immediately, 1 year and 5 year	ION (V1)	Eyelid	Light touch, mechanical detection threshold	Current perception threshold	Patient's report
Scott, 2014[16]	N	Y	Minimum of 12 months, maximum not specified	IAN (V3)	Lower lip	Light touch	NE	Questionnaire and scale (0-10)
Mayrink, 2012[17]	Y	Y	1 week,1, 3, 6 months and 1year	IAN (V3)	Labial commissure, chin and horizontally by labial inferior border, mentolabial folder and lower border of mandible	Static light touch, brush directional stroke	Thermal discrimination and pin- prick	Questionnaire
Bagheri, 2009[18]	Y	Y	After trauma, pre-op, 1 week, 1, 3, 6 months and 1 year	IAN (V3), ION (V1), LN (V3) and BN (V3)	ND	Static light touch, moving brush strokes, stimulus localization, static 2-point discrimination	Painful stimuli	Patient's report
Sakavicius, 2008[19]	Y	Y	2 weeks, 1, 3, 6 and 12 months	ION (V1)	nose, cheek, lower eyelid, upper lip, gingival and teeth	NE	Pain detection threshold	Patient's report and clinical symptoms
Barry, 2007[20]	Y	Y	ND	IAN (V3)	ND	2-point discrimination, direction sensation	Thermal sensation	Questionnaire
Iizuka, 1991[21]	Y	Y	6.2 weeks and 15.9 months on average	IAN (V3)	Chin and lower lip	Light touch (with cotton wool)	Pinprick (sharp/blunt differentiation with a sharp dental probe)	Patient's report
Fogaça, 2004[22]	N	Y	NE	ION (V1)	Zygomaticotemporal region, paranasal region, and upper lip	Static and moving-touch discrimination, static two-point discrimination	NE	Patient's report

Continue

Continuation

Leonhardt, 2005[31]	Germany	Prospective Cohort	Mean 31 (ranged 15 to 70)	30	ND	Angle and ramus	ORIF	Intraoral
Marzola, 2006[32]	Brazil	Prospective Cohort	Range 11 to 51	100 (19/81)	Interpersonal violence (23%) Traffic accidents (37%) Domestic accidents (16%) Sports accidents (6%) Working accidents (4%) Others (14%)	Zygomaticomaxillary complex fracture	ORIF or conservative	ND
Ahmed, 2010[33]	India	Prospective Cohort	From 20 years	133 (3/130)	ND	Zygoma	ND	ND
Vriens, 1998[26]	N	Y	Average 6.3 m (SD 2.6, range 3-12 months)	ION (V1)	Cheek, on hair-bearing skin of upper lip	Static touch, static two-point discrimination	Cold sensation and pinprick	Patient's report
Kipper, 2016[27]	Y	N	NE	ION (V1)	Cheek and upper lip	Static touch	NE	questionnaire
Fogaça, 2008[28]	N	Y	NE	ION (V1)	Zygomatic region, paranasal region, upper lip	Static two-point discrimination,cutaneous pressure threshold (static point), cutaneous pressure threshold (dynamic point), cutaneous pressure threshold (static two-point), cutaneous pressure threshold (dynamic two-point)	NE	Patient's report
Kesarwani, 1989[29]	N	Y	1y (mean testing time: 3y)	Supraorbital nerve (V1), ION (V1), IAN (V3)	Forehead, cheek, chin and the vermilion of the lower lip	Moving and static two-point discrimination, vibratory, cutaneous pressure thresholds	NE	Patient's report and vibratory perception
Abd El-Kader, 2011[30]	Y	Y	2 and 12 weeks	ION (V1)	Lower eyelid, lateral skin of the nose, upper lip	Trigeminal somatosensory evoked potential (TSEP)	NE	Qestionnaire

Continue

Continuation

Leonhardt, 2005[31]	Germany	Prospective Cohort	Mean 31 (ranged 15 to 70)	30	ND	Angle and ramus	ORIF	Intraoral
Marzola, 2006[32]	Brazil	Prospective Cohort	Range 11 to 51	100 (19/81)	Interpersonal violence (23%) Traffic accidents (37%) Domestic accidents (16%) Sports accidents (6%) Working accidents (4%) Others (14%)	Zygomaticomaxillary complex fracture	ORIF or conservative	ND
Ahmed, 2010[33]	India	Prospective Cohort	From 20 years	133 (3/130)	ND	Zygoma	ND	ND

Legend: NE: Not Evaluated; ND: Not Described; IAN: Inferior Alveolar Nerve; ION: Infraorbital Nerve; LN: Lingual Nerve; BN: Buccal Nerve;

Procedures and measurements

As for subjective assessment, it is always performed before the objective clinical examination, from touching the affected region, using materials, or the gloved hand. The subjective assessment was carried out based on the patient's report, spontaneously (61.90%) or guided by structured questionnaires (33.33%), or using scales created for the respective studies (9.52%). When assessments based on the reports are used, they could take place from unstructured conversations between the researcher and the patient or contain questions with yes or no answers. The questions were related to changes in sensitivity, numbness, burning and tingling sensation, thermal sensitivity, pain, functional changes (mainly during feeding, such as bites on the lips and escape of food from the oral cavity) and interference in the individual's daily life and quality of life. Some studies guide the comparison of sensory differences on the injured side with a region of the face with uninvolved innervation or a sensitive region of another part of the body. The use of scales suggests that the patient classifies the change in categories. The most common are represented visually by numbers, where zero corresponds to the absence of sensory complaints, and ten/hundred corresponds to severe sensory changes. For the subjective assessment to be reliable, the patient's report must be considered. For this, the evaluator must investigate the sensory complaint, asking the patient to explain and describe the altered sensation.

As for the objective assessment, studies advise that patients should be examined in a quiet room, with their eyes closed and in a comfortable position, preferably with a headrest. For each type of assessment, procedures are cited for carrying out the different measurements proposed. The studies bring the following measurements and procedures/techniques for assessing touch and nociceptive sensation:

- *Light touch/static light touch* (61.90%) - assessment of detection of light touch stimulus (slowly-adapting nerve fibers): *OptiHair von Frey filaments* (*MARSTOCK nerve test, Marburg, Germany*)[14], *Semmes-Weinstein monofilament* (esthesiometer)[15,17,28,28], *0.7-mm-gauge needle* (*BD Precision GlideTM*)[17], *Pressure-Specified Sensory Device* (PSSD)[22,28] and *Cotton roll*[25];

- *Mechanical detection threshold* (19.04%) - a gradual measurement of the detection of light touch stimulus, of ascending and descending character to determine the threshold (slowly-adapting nerve fibers): *OptiHair von Frey filaments* (*MARSTOCK nerve test, Marburg, Germany*)[14] and *Semmes-Weinstein monofilament* (esthesiometer)[15,28,29];

- *Direction sensation* (14.28%) - assessment of the detection of the direction of movement, differentiation of movements up, down, right or left (rapidly-adapting nerve fibers): *0.7-mm-gauge needle* (*BD Precision GlideTM*)[17] and *Dental cotton swab*[25];

- *Two-point discrimination - static or moving* (47.62%) - assessment of the minimum distance between two static points (slowly-adapting nerve fibers) or moving (rapidly-adapting nerve fibers) that the patient can discriminate: *Pressure-Specified Sensory Device* (PSSD)[22,28], *MacKinnon-Dellon Disk-Crimínator®* (*North Coast Medical, Inc.*) or *Aesthesiometer 2 point*[26,28,29];

- *Vibratory sensation* (4.76%) - assessment of the detection of vibration and determination of the threshold of the disappearance of the stimulus (rapidly-adapting nerve fibers): *Vibrometer* and *256-cps tuning fork*[29];
- *Thermal discrimination* (9.52%) - detection of temperature differences and determination of cold or hot stimuli. *Cotton-tipped applicator saturated with a spray freeze of -50°C temperature*[17], and *Ethyl chloride vapor was sprayed onto a spherical dental cotton bud (cold sensation) (diameter: 5 mm)*[26];
- *Painful stimuli/pinprick* (33.33%) - assessment of painful stimulus detection: *needle held the between thumb and index finger*[17] and *27-gauge needle*[25];
- *Pain detection threshold* (14.29%) - a gradual measurement of the detection of painful stimuli, of an ascending and descending character to determine the threshold (aid in the determination of hypoalgesia): *Neurometer CPT* (*Neurotron Inc*)[15]and *Non-invasive electrocutaneous stimulation*[19];
- *Sensory assessment/ sensory changes*:
    - Assessment of sensorineural deficits of the inferior and mental alveolar nerves: *Thermography*[25] (4.76%);
    - Assessment of nerve function latency and amplitude: *Trigeminal somatosensory evoked potential*[30] (4.76%).
    - Details on how to conduct facial sensitivity assessment procedures described in the articles are listed in Appendix 2.

It was not possible to carry out a meta-analysis because the studies did not have sufficient quantitative data and showed high qualitative heterogeneity in the aspects of nomenclature, procedures, and equipment used in the sensitivity objective assessment procedures.

DISCUSSION

In this study, we found a varied number of procedures used to assess each sensory modality. Considering the high incidence of traumatic events that cover the facial region[1-3,14,16,17,25] and the occurrence of sensitivity changes resulting from these episodes[9,10,13-33], it is necessary to have tests that assess these changes accurately.

Bearing in mind that the subjective procedures were considered as reference tests in this review, it was identified that this assessment occurs in a very different way, using questionnaires with questions aimed at guiding the patient's report and/or scales to measure the degree of reported impairment. In both assessment modalities, difficulties related to the interpretation and classification of the changes mentioned by the patient are found, and the results are subject to inappropriate analyzes, distortion of the report, and inadequate diagnoses of the change. Also, there is qualitative heterogeneity in the scales used by the authors, who create scales for the punctual assessment using variations of the visual analog scale[14,16]. Based on this, what is effective in most studies is the realization of a questionnaire with structured questions[13,17,20,27,30,33] and the consideration of the patient's report as a marker of change[15,18,19,21-26,28,29,31,32] to guide the use of objective tests.

The objective assessment of facial sensitivity must be seen as a complement to the subjective assessment, and it must involve a large number of procedures that can be listed according to the type of nerve fiber tested, touch, and nociceptive sensitivity (pain and temperature). Most of the articles used the touch assessment as the main parameter in the profile of the peripheral innervation integrity of the face, being[13,15,16,20,21,25,26,30,32] or not[14,17,18,22-24,27-30,33] associated with nociceptive assessment. About touch assessment, the method used in most studies is the detection of *light touch stimulus,* usually associated with the *mechanical detection threshold,* with the use of monofilaments with force values already standardized for measuring cutaneous sensitivity thresholds. The method allows a gradual assessment of impairment and nervous recovery over time, in cases where there is a follow-up after the intervention[14,15,17,27,28,30]. The nociceptive assessment, on the other hand, verifies the nerve fibers involved in the sensation of pain and temperature. The studies present greater verifications of the painful sensation[13,15,17-19,21,25,26,31,32], eventually being accompanied by the sensation of temperature[17,26,31]. Regarding these modalities, when researching the sensation of pain, studies use the prick test[13,17,18,21,25,26,32], and when researching the sensation of temperature, they determine if the patient differentiates cold and hot stimuli[17,26]. A limiting factor of these assessments refers to the lack of consensus on the indication of specific instruments to carry out the tests, using heterogeneous equipment, which results in several protocols.

Thus, based on the studies, a minimum battery of facial sensitivity assessment is proposed with the modalities and procedures that should be performed so that the applicator has a complete overview of the patient's peripheral nervous situation and the regions affected. Assessments should be carried out, if possible, preoperatively and postoperatively (in cases of surgical intervention)[15,17-21,25,30,31] because it is known that the changes may be the result of trauma or type of surgical treatment used[21]. In the postoperative period, it is suggested that re-assessments be made in the first week[13,15-19,23,24,26,29-33], in the first month[13,17-19,23,31-33], in the third month[13,17-19,23,24,30,31,33], in the sixth month[17-19,23,26,31-33], and in the first year[15-19,23,29,33] after surgery or trauma. It is recommended to start with the subjective assessment, which is important to identify the patient's complaint and to delimit what results are expected from the objective tests later. At this stage, it is suggested questions to guide the patient's report (Chart 1).

Chart 1. Questions to guide the patient's report

Questions to guide the patient's report:
1. Do you notice changes in the sensitivity of the face?
2. Do changes in sensitivity involve numbness, burning, tingling, pain or sensitivity to cold? Can you explain with your words how the sensation is?
3. Are your functionality and quality of life impaired? In what situations? (situations can be exemplified for the patient, such as: food runs through the mouth, drooling, biting of the lips.)
4. Comparing with the unaffected side (or with some other region of the face, in cases of bilateral fracture), do you feel differences in sensitivity?

After establishing the face sensitivity profile based on the patient's report, progress should be made with the objective assessment. It is necessary to confirm the patient's report, since changes, even if slight, may be present despite the patient not reporting complaints. In the objective assessment, it is necessary to perform procedures of the touch and nociceptive modalities, to stimulate different receptors and nerve fibers. The touch modality verifies the integrity of the mechanical facial receptors that involve Aβ fibers, performing the stimulation of the Merkel disc and the Ruffini corpuscle, responsible for detecting rapidly and slowly-adapting touch stimuli; and Meissner corpuscles and *hair follicle fiber*, which are involved in the transduction of nerve signals. The nociceptive modality (perception of pain and temperature) is not mediated by the receptors of the corpuscles so that the Aδ and C fibers are involved in the transmission of these sensory modalities[4]. Thus, in the case of touch stimulation, it is recommended, due to the frequency of use in the articles included and the ease of application, the *Light touch/static light touch* test and, consequently, the *Mechanical detection threshold*, which can also be performed according to the instrument used for checking (if monofilaments are used). These tests will allow the stimulation of corpuscular receptors and stimulation of Aβ fibers[4]. For nociceptive stimulation, the use of the *prick test* or *thermal stimulation* is recommended. However, it is emphasized that for proper stimulation and central transmission of painful stimuli, cutaneous thresholds must be between 23g and 51g, and if thermal stimulation is used, temperatures below 0°C or above 47°C[4]. The tests are carried out with the patient with eyes closed, informing the applicator from which point the stimulation is perceived.

In conclusion, The instruments for investigating facial sensitivity used in the clinic in cases of maxillofacial trauma involve, for subjective assessment: the patient's report guided by structured questions; and for objective assessment: predominantly the evaluation of touch and nociceptive sensitivity, the latter also comprising thermal evaluation. From this, it is proposed a standardization to investigate changes in facial sensitivity. Besides, the study of the profile of these changes contributes to the improvement of surgical techniques and to a safe return about the long-term results of the patient's sensory situation[14].

Limitations

It was not possible to carry out a meta-analysis of this systematic review because the included studies did not have sufficient quantitative data for registration in contingency tables. Also, they showed high qualitative heterogeneity in the aspects of nomenclature, procedures, and equipment used in the sensitivity objective assessment procedures. For this, more studies should investigate the validity of the tests used in practice, to favor the use of effective diagnostic procedures, since the accuracy analysis of the tests was not possible due to the low availability of data in the studies.

CONFLICTS OF INTEREST STATEMENT

No conflicts of interest exist.

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Appendix 1

PubMed Search

	Search strategy	Hits
#1 Facial fractures	**Maxillofacial Injuries[MeSH Terms]) OR Maxillofacial Fractures) OR Maxillofacial trauma) OR Maxillofacial Injury) OR Maxillary Fractur*) OR Maxillary Fractures[MeSH Terms]) OR Facial Injuries[MeSH Terms]) OR Facial Injury) OR Facial fractur***	59.092
#2 Maxilla fractures	**Zygomatic Fractures[MeSH Terms]) OR Zygomatic bone fracture) OR Zygomatic Fracture) OR Zygomatico-orbital fracture) OR Zygoma Fractures) OR Zygomatic complex fractures) OR Blow-Out Fractures) OR Orbital Fractures[MeSH Terms]) OR Orbital Fractur*) OR Orbitozygomatic complex) OR Orbitozygomatic fractur***	6.641
#3 Jaw Fractures	**Jaw Fracture[MeSH Terms]) OR Jaw Fractur*) OR Mandibular Fractures[MeSH Terms]) OR Mandibular Injuries[MeSH Terms]) OR Mandibular Injur*) OR Mandib* fractur*) OR Mandibular condyle fracture) OR Angle fracture) OR Multiple mandibular fractures) OR Mandibular trauma) OR Condyle fractures**	102.187
#4 **Patient**	#1 OR #2 OR #3	144.953
#5 **Tests and outcomes**	**Sensation Disorders[MeSH Terms]) OR Somatosensory Disorders[MeSH Terms]) OR somatosensory function) OR cutaneous sensibility disturbances) OR Allodynia) OR Dysesthesia) OR Paradoxical heat sensation) OR facial sensibility testing) OR cutaneous sensibility) OR facial sensibility) OR sensib*) OR cutaneous sensory function) OR Sensory profile) OR Somatosensory nervous system**	247.230
#6 **Search**	#4 AND #5	4.412

Google Search

Fraturas Maxilomandibulares OR Fraturas Mandibulares OR Fraturas Maxilares OR Fraturas Orbitárias OR Fraturas Zigomáticas = 2.030

Lilacs, OpenGrey and ProQuest Search

Fraturas Maxilomandibulares OR Fraturas Mandibulares OR Fraturas Maxilares OR Fraturas Orbitárias OR Fraturas Zigomáticas = 0

Cochrane

	Search strategy	Hits
#1 Facial fractures	**Maxillofacial Injuries [MeSH Terms] OR Maxillofacial Fractures OR Maxillofacial trauma OR Maxillofacial Injury OR Maxillary Fractur*[MeSH Terms] OR Facial Injur*[MeSH Terms] OR Facial fractur***	1288
#2 Maxilla fractures	**Zygo* Fractur*[MeSH Terms] OR Zygomatic bone fracture OR Zygomatico-orbital fracture OR Zygomatic complex fractures OR Blow-Out Fractures OR Orbital Fractur*[MeSH Terms] OR Orbitozygomatic fractur***	148
#3 Jaw Fractures	**Jaw Fractur*[MeSH Terms] OR Mandibular Injur* OR Mandib* fractur[MeSH Terms] OR Mandibular condyle fracture OR Angle fracture OR Multiple mandibular fractures OR Mandibular trauma**	1022
#4 **Patient**	#1 OR #2 OR #3	2105
#5 **Tests and outcomes**	**Sensation Disorders[MeSH Terms] OR Somatosensory Disorders[MeSH Terms] OR cutaneous sensibility disturbances OR Allodynia OR Dysesthesia OR Paradoxical heat sensation OR facial sensibility* OR cutaneous sensibility OR sensib* OR cutaneous sensory function OR Sensory profile OR Somatosensory nervous system**	5478
#6 **Search**	#4 AND #5	224

EMBASE Search

	Search strategy	Hits
#1 Facial fractures	'maxillofacial injury'/exp OR maxillofacial) AND fractures OR 'maxilla fracture'/exp OR 'face injury'/exp OR 'face fracture'/exp	68.385
#2 Maxilla fractures	'zygoma arch fracture'/exp OR 'orbit fracture'/exp	5.745
#3 Jaw fractures	'jaw fracture'/exp OR 'mandible fracture'/exp	10.000
#4 **Patient**	#1 OR #2 OR #3	68.531
#5 **Tests and outcomes**	'sensory dysfunction'/exp OR 'somatosensory disorder'/exp OR 'allodynia'/exp or 'dysesthesia'/exp	573.362
#6 **Result**	#4 AND #5	8.764

#7 **Age**	#6 AND ([adult]/lim OR [aged]/lim OR [middle aged]/lim OR [very elderly]/lim OR [young adult]/lim) AND [embase]/lim NOT ([embase]/lim AND [medline]/lim)	**1.097**

Appendix 2. Facial sensibility procedures

Instrument	Modality	Method
OptiHair von Frey filaments (MARSTOCK nerve test, Marburg, Germany)[10]	Static light touch and mechanical detection threshold	Examinations were started on the uninjured side on unilateral fractures. The filaments were applied perpendicular to the face in a descending order of magnitude to assess the threshold at which sensation disappeared. Procedure was repeated four times.
Semmes-Weinstein monofilament (estesiometer) [11, 13, 23, 24, 25]	Static light touch and mechanical detection threshold	Monofilament is placed perpendicular to the skin and pressed until the filament begins to deform. The monofilament gently touched the skin and patients were asked about sensibility. Each measurement was repeated 3/4 times and filament was applied for 1.5 seconds, held for 1.5 seconds, and released for 1.5 seconds. If the patients were able to feel the monofilament minor caliper, testing ceased. If they were unable, the test followed until the patient could feel the monofilament touching the skin.
Neurometer CPT (Neurotron Inc) [11]	Current perception threshold (identify and evaluate nerve fiber damage - sense of pressure, temperature and pain)	Fixing an electrode to the test site using the attached tape. Two different current intensities were passed from the electrode to the patient, who was then asked to say which current the patient believed was stronger. Minimum perceivable current was measured when an electrical stimulation at 2,000, 250, or 5 Hz was applied. The measurements were taken 3 times at each frequency.
0.7-mm-gauge needle (BD Precision GlideTM) [13]	Static light touch (SLT) and brush directional stroke (BDS)	SLT: The needle gently touched the skin, and the point that the patient feel sensibility was noted. BDS: It was applied in a 1-cm stroke in each point. The examiner decided if move it from right to left or from left to right in each interval, and the patient was asked about the direction of the movement.
A needle held the between thumb and index finger [13]	Pinprick discrimination	The intensity was applied sufficiently so the patient would feel pain or to draw as small drop of blood at the puncture side.
Cotton-tipped applicator saturated with a spray freeze of −50 °C temperature [13]	Thermal discrimination	The patients were asked about cold or normal/not cold feeling immediately upon application of each respective applicator.
Non- invasive electrocutaneous stimulation [15]	Pain detection threshold (PDT)	Is performed applying noninvasive electrocutaneous stimulation of the dry skin in the region by active 2 mm diameter electrode and passive electrode fixed by patient's hand's thumb and forefinger. PDT was assessed using ascending method of limits. The stimulating current was gradually increased by fixed rate until the subject indicated first pain sensation. Three PDTs were evaluated.
Pressure-Specified Sensory Device (PSSD) [18, 25]	One-point static discrimination, two-point static discrimination and moving-touch discrimination	The small blue PSSD is hand held by the person doing the testing, and the two small metal probes are touched gently to the skin area being tested. The cutaneous pressure thresholds for one-point static and moving-touch discrimination were recorded in grams per square millimeter, and the pressures required for two-point static and moving-touch discrimination were recorded as the pressure for a given interprong distance (in millimeters).
Cotton roll [22]	light touch sensation	Not described
27 gauge needle [22]	Pain test	Not described
Dental cotton swab [22]	Directional test	Not described

Thermography [22]	Sensory changes	Each subject was asked not to eat, drink, or smoke for an hour before the examination. All cosmetics were washed off and the skin surface allowed to dry in the air. Hair was held off the face with hair grips. No sources of radiation were allowed in this environment and sunlight was excluded. All air convection sources were minimized and only two operators were allowed into the room while the examination was in progress. Once stabilized, baseline measurements were recorded for the frontal and left and right profiles of each patient in a sitting position at a focal distance of one metre perpendicular to the region of interest.
MacKinnon-Dellon Disk-Crimínator® (North Coast Medicai, Inc.) or Aesthesiometer 2 point [23, 25, 26]	static two-point discrimination and moving two-point discrimination	Series with either ascending or descending increments with a successively longer or shorter pin distance in the device, during which the subject 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 a stimulus increment was followed by two responses of the opposite type on successive increments. Each of the tests consisted of four alternating series. - The initial two point testing distance was 24 mm, proceeding in stages down to 2mm. The stimulus was randomly alternated between one and two points. If the patient correctly perceived the changes, the distance was decreased. This testing pattern was continued until the patient answered incorrectly, at which time the observer returned to the next higher distance. In the two-point limit, two of three correct answers were required for this distance to be chosen as the end-point.
Ethyl chloride vapour was sprayed onto a spherical dental cotton bud (diameter: 5 mm)[23]	Cold sensation	After ice crystals had been formed, the bud was placed on the test site for at most 1 s. The drop in temperature varied within a range from 22 to 24~ at the interface between cotton bud and skin.
Vibrometer [26]	vibratory threshold	Using a fixed-frequency (120Hz) variable amplitude instrument. The vibrating portion of the instrument was applied to the test area, and the voltage was gradually increased until the patient was first able to perceive vibration. The threshold is converted into microns (amplitude) of displacement.
Trigeminal somatosensory evoked potential (TSEP) [27]	Sensory assessment	The recording electrode was placed contralateral to the side of stimulation 2cm posterior to C3 and C4 at the coronal suture. A reference electrode was placed at mid frontal site and the array was earthed by ground electrode placed around neck. The electrical stimulator provided stimuli at a rate of 2 sec and each stimulus lasted for 0.1 sec. The stimulus intensity was adjusted by gradual increasing up to the level where minimal lower eye lid twitch could be observed. In order to achieve pure sensory stimulation with maximum activation of the nerve fibers and minimum electrical artifact, the Infra-Orbital Nerve (ION) stimulation was performed at the ION foramen using the stimulator electrode of TSEP. TSEP was at least repeated twice to confirm the reproducibility and reliability of the response;