Research Article **Open Access**

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Distraction techniques for face and smile aesthetic preventing ageing decay

DOI 10.1515/med-2016-0077
received August 11, 2016; accepted August 23, 2016

Abstract: Modern concepts in the world of beauty arise from popular models, beautiful faces of actors document a bi-protrusive asset with high tension for soft tissues. Facial symmetry has been proposed as a marker of development and stability that may be important in human mate choice. For various traits any deviation from perfect symmetry can be considered a reflection of imperfect development. Additionally, bi-protrusive profile is dependent on the hormonal level regardless of male or female sex. The goal of maxillofacial surgery is to provide best results both for aesthetic and functional aspects. Following these new concepts of aesthetic of the face, new surgical procedure by osteodistraction techniques will lead to a very natural result by harmonizing the face also preventing aesthetic decay in aging faces. Ten cases with a feedback on the aesthetic results using the five-point scale of Likert after orthognatic surgery performed following distraction new techniques in combination with ancillary surgical procedures.

The aesthetic results in all patients were highly satisfactory. All the patients accepted the new aesthetic of the face avoiding elements of discrepancy and consequently medico-legal problems.

Keywords: Aesthetic; Facial attractiveness; Osteo-distraction; Facial symmetry

1 Introduction

Aesthetic perception of the face has greatly changed in relation to common standards of the past. Standard beauty of the face in paintings and sculpture in the past showed redundant amount of soft tissue in relation to face skeletal dimension. This was probably due to the lack in food availability for large part of the population and area. For this reasons the popular standard beauty was a round face with high ratio soft tissue/skeleton of the face. Since past, what makes a person attractive has been one of the most favorite questions in both fields such as social and natural sciences. The question is interesting beyond personal considerations, given the importance of attractiveness in human social interactions [1,2].

Modern concepts of beauty from popular models of beautiful faces from actors show a bi-protrusive aspect with high tension for soft tissues. This is probably due to large availability of food resources for most of the population. Large skeletal dimension for bi-protrusive face model is significant for a good genetic asset of the patient with total expression of skeletal growth abilities in association with a well-expressed sexual hormone level [3].

Furthermore, symmetry refers to the extent by which one-half of an object is the same as the other half [4]. Facial symmetry has been proposed as a marker of developmental stability that may be important in human mate choice. Several studies have demonstrated positive relationships between facial symmetry and attractiveness. Researcher have proposed that symmetry and sexual dimorphism in human faces (masculine appearance in men and feminine appearance in women) may be cues to heritable fitness benefits and therefore relate to attractiveness [5].

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Also, symmetry has long been proposed to be associated with male and female genotypic quality [6]. For many traits any deviation from perfect symmetry can be considered a reflection of imperfect development. It has then been suggested that only high-quality individuals can maintain symmetric development under environmental and genetic stress, and therefore, symmetry can serve as an indicator of phenotypic quality as related to a good genotypic asset [7-10]. Masculine facial traits with large jaws and prominent brows in males are thought to be testosterone dependent and therefore may represent an immune-competence asset signaling quality [11].

Indeed masculine-faced men do report having lower incidence of disease [12], and therefore should be found attractive by members of the opposite sex [8]. Although there is some evidence that masculine male faces are found attractive [13,14], several studies have shown that feminine faces and faces of low dominance are also attractive [15,16]. This suggests that male facial attractiveness preference may depend on more than just cues to "good genes" for immune-competence, for example stability of relationships for females with low self-esteem [17].

Male and female faces differ in their shape. Mature features in adult human faces reflect the masculinization or feminization of secondary sexual characteristics that occurs at puberty. These face shape differences, in part, arise because of the action of hormones such as testosterone. Larger jawbones, more prominent cheekbones and concave cheeks with well represented masseter muscles are all representing features of male faces that differentiate them from female [18].

There is considerable consensus that feminine female faces are considered attractive. Studies measuring facial features from photographs of women [8,19] and studies manipulating facial composites [20], all indicate that feminine features increase the attractiveness of female faces for males across different cultures. If female faces under high estrogen levels provide cues to fertility and health, then male preferences for such features are potentially adaptive.

Bi-protrusive profile is dependent on the hormonal level irrespective of sex. Just like the body of a muscular man is considered an aesthetically attractive type, which is indicative of a well-expressed hormonal status, also a well-represented facial skeleton is demonstrative. Therefore, it is justified that the attraction for a bi-protrusive profile with concave cheeks in which the jaws have three-dimensional development with maximum expression of the chin, the lower border of the mandible, and large alveolar, dental and zygomatic arches. For this reason the aesthetic models always show a concave cheek line with prominent cheekbones (often enhanced by plastic surgery), well-represented mandibular arches with evident lower margins, often obtained with chin surgery or innovative mandibular advancement, and extensive dental arches in line with the new concepts of smile aesthetic.

Modern smile aesthetic avoids black corridors, looking for a moderate exposure of the upper jaw attached gingiva, suggestive of a young person with good development of the dental arches and jaws [21,22].

Lips well supported by the dental arches are representative of a young person and this aspect is associated with large sized teeth, it is indicative of an excellent chromosomal asset. In order to obtain an optimal facial beauty in line with the new models of aesthetics, new osteo-distractive maxillofacial surgical techniques aimed at increasing jaw and dental arches size have been developed.

Therefore, in light of above our research group developed original techniques to obtain transverse increase and antero-posterior repositioning of the jaws in one surgical stage.

For the mandible, innovative surgery techniques have been developed such as mandibular distraction with advancement and rotation of the occlusal plane using 3-D intraoral distractors and chin surgery extended to the entire lower border [23,24,25]. In this technique, a complete reshaping of the lower third of the face was achieved by a sandwich osteotomy with interposition of autologous bone graft from the iliac crest.

In order to scientifically validate the aesthetic and functional results, our research group submitted pre-operative, immediate post-operative and 2-years post-operative pictures to a group of 20 students to get feedback of the aesthetic results on a five-point scale.

Ultimate goal of Maxillofacial surgery should be to achieve the best results both for aesthetic and functional aspects; in this way patients will attain full satisfactory results, thereby accepting their new aesthetic of the face and subconscious new identity repealing their previous shape face identity.

Adapting these new surgical procedures the new aesthetic of the face will lead to a very natural final result making harmonious what was not and thus mimicking optimal gene expression.

Because surgical mandibular advancement is strictly associated to TMJ dysfunction and condylar resorption, surgical planning has to properly manage these risks.

Scientific consensus about risk for condylar resorption indicates increasing risks for large (more then 10 mm) mandibular advancement in young females patients showing dolichofacial patterns and thin back-tilting con-

dyles: in such cases mandibular advancement is very dangerous because of possible resorption of the condyles with related class II malocclusion relapse.

To overcome these risks Arnett et al. used vertical midline bone anchored elastic forces with associated class 2 elastic forces to avoid gonial angle opening. In the same study Arnett has also proposed cephalometric evaluation of the concavity of the cheek (S line) to improve it following the maxillofacial surgical step [26,27].

Criteria we followed in the surgical planning were aimed to normalize dental and skeletal class relations, considering the symmetry of the jaws and dental arches.

Planning was also aimed at achieving optimal aesthetic in relation to the new facial concepts of beauty with emphasis on the continuity of the mandibular border without any irregularities in the sites of the osteotomy lines, good projection of the gonion and the zygomatic arches, open nasolabial angle, large width and proper height of the smile.

About the characteristics of the lower jaw border, we consider particularly significant its projection in relation to a good tension of the skin for a youthful appearance of the face and in relation to optimal chromosomal and hormonal asset.

In the cases operated by traditional orthognatic techniques like bilateral sagittal split osteotomy (BSSO), defects and bad alignment are frequently detected both at x-ray controls and at aesthetic evaluation. These bad alignments are frequently seen when large advancement with counterclockwise rotation of the occlusal plane are performed. These conditions particularly happen when anterior osteotomy site is placed forward at the 1st or 2nd molar region due to large bone contact need for large advancement of the mandibular arch. Following the modern concepts of aesthetic of the face aiming at bi-protrusive faces with high tension of the skin and good definition of facial skeleton contour, large bimaxillary advancement with counterclockwise rotation of the occlusal plane are commonly planned in orthognatic surgery following the recent techniques by Arnett [26,27]. In these cases an angle is detected in the lower border of the mandible at the anterior osteotomy site of the BSSO, with aesthetic decay of the face because of cheek folds resembling ageing faces.

Concerning gonial regions projections they can be expression of good chromosomal and hormonal asset showing good skeletal development. Gonion projection must not be excessive in female patients because it shouldn't express excessive masculinity, but must be sufficiently represented because lack in lower border and gonial mandibular evidence is proper of the pre-pubertal age. Deficiency in gonion projection is sometimes detected in traditional orthognatic surgery when a gonial angle opening occurs following failed stability of mandibular osteotomy fixation. This complication causing post-surgical relapse may occur because of the forces that act at the gonion region: all the jaw elevator muscles are inserted in the proximal fragment of the BSSO and all depressor and retrusor muscles are inserted in the mandibular arch with high stress of the BSSO fixation. Other problems causing gonial region bone resorption after BSSO are related to excessive muscle detachment of the masseter and pterigoyd muscles or bicortical screw fixation at the gonial region with improper tightening of one screw causing bone fragment compression and lack in nutrition in both cases.

In relation to zygomatic arch projection, similarly to the mandibular arch, it is indicative for good hormonal (projection) and chromosomal (symmetry) asset. Also, in these cases a good zygomatic arch projection is suggestive of young age with good skin tension and sexual hormonal levels particularly in males. Additionally, continuity in zygomatic arch profile is needed for a natural and aesthetic appearance.

A wide nasolabial angle is significant for the new concept of aesthetic of the face because it signifies optimal growth of the maxillary bones in relation to good hormonal (projection) and chromosomal (symmetry) assets.

By the aesthetic point of view good projection of the maxillary bones is associated to a good aesthetic of the nasal profile because of the tip alar cartilage projection by the ANS (anterior nasal spine) on the medial alar cartilage crus. Large and anteriorly projected maxillary bones are also related to good aesthetic of the mouth and cheeks by a good support of the upper lip and nasolabial folds suggesting young and healthy age with completely represented dental arches.

In consideration of smile aesthetic and symmetry a good hormonal and chromosomal asset is associated to a large smile without black corridors showing well-represented alveolar bones, large sizes teeth and a proper height of the smile with 2 millimeters of gum exposure at full smile for the upper jaw.

Two millimeters of gum exposure at smiling is suggestive of young age when facial soft tissues have not yet undergone age decaying with the natural loss of dermal elasticity characteristic of elderly age with skin excess. Also in smile appearance chromosomal asset will be expressed in large size teeth with symmetry in teeth and bone arches.

Following this concept, orthodontic and surgical therapy planning has to perceive correction of teeth crowding without teeth extraction to avoid alveolar and dental arch collapse detrimental for smile and face aesthetic.

Following modern concepts of the smile and face aesthetic, orthodontic and surgical therapy planning has to obtain skeletal and dental discrepancy resolution by basal and alveolar bone enlargement following the new surgical techniques of bone distraction. In this way it will be possible to obtain resolution of dental crowding without extraction, avoiding post surgical and orthodontic facial decay commonly detected in therapy plans with teeth extractions. Resolution of teeth-crowding and jaw contraction has to be obtained by orthodontic (in pre-pubertal age) and orthodontic-surgical (post-pubertal age) therapy by jawbone expansion such achieving stable teeth alignment without periodontal or smile and aesthetic decays.

This kind of planning, aimed to obtain maximum skin tension by skeleton enlargement and harmonization will also prevent facial decay in aging faces.

The aim of this study was to detect aesthetic results on ten cases operated for skeletal discrepancies by maxillary distraction and repositioning in one stage and mandibular distraction. To obtain this goal we performed the aesthetic evaluation of pre-operative, post-operative and two years post-operative results on 10 cases operated by advanced distraction techniques.

2 Materials and methods

To evaluate aesthetic results of 10 cases (n=10) operated with distraction techniques, our research group submitted pre-operative, immediate post-operative and 2-years post-operative pictures to a group of 20 students to get feedback on the aesthetic results using the five-point scale of Likert.

The ten cases were composed by seven cases of III class with maxillary collapse operated by distraction and repositioning in one stage and three cases of II class treated with maxillary expansion and mandibular advancement following the new distraction techniques. The group of twenty people selected for case evaluation, was composed of medical doctor students ranging from 20 to 25 years old of both sexes (10 males and 10 females).

The group of students evaluated pictures in frontal left side, right side and oblique right and left side for each patient for face and smile. Evaluation was performed filling out a questionnaire and using a five-point Likert scale (1=very unattractive and 5=very attractive).

Ten cases of orthognatic surgery have been performed following distraction new techniques in combination with ancillary surgical procedures. Seven cases were subjected to maxillary bone distraction and repositioning in one stage in III class malocclusion. Three cases showing II class malocclusion with heavy discrepancy (overjet > 10 mm) were subjected to mandibular distraction by intraoral three-dimensional distraction and ancillary surgical procedures.

In the seven cases of maxillary distraction a Le fort I osteotomy with down-fracture, midline osteotomy, advancement and repositioning of the maxillary bones in one stage and distraction by 4 screw bone anchorage distractor device was performed following the Cortese techniques [28-30].

Bone anchored osteodistractors were used in a segmented, complete Le Fort I surgery; maxillary bones were fixed in the new position by a semi-rigid fixations following the Cortese technique [31-34] .

For this reason four L shaped miniplates with long vertical arms, four holes and only three screws for each plate were used with only one screw in the upper hole of the vertical arms and two screws on the horizontal arms.

In this way it was obtained a semi-rigid fixation in the transverse dimension and a rigid fixation in the antero-posterior direction to allow transverse expansion during distraction in association with an antero-posterior stable repositioning of the jaws in a single time.

Palatal distractor was constructed casting a titanium jackscrew (Dentaurum gmbh & co.) with four one-hole miniplates (Stryker) fixing the device in the paramedian site of the palate by four self-locking screws to achieve a rigid system with full control of the maxillary distraction in the three planes of the space.

In the other 3 cases of mandibular advancement and distraction an intraoral three-dimensional distractor device anchored by screws on the proximal fragments (ramus) and the distal fragment (arch) of the osteotomy site was used.

A mandibular distractor device (Orthognathics GmbHBellerivestrasse34 348008 Zürich), which allows three-dimensional distraction by three telescopic screws in the three planes of the space, was fixed after pre-gonial angle osteotomies on both vertical ramus and mandibular arch by bi-cortical screws. After seven days of healing time, distraction started at one mm/day rate divided in two activations every day for the number of days necessary to achieve final result with little overcorrection of the malocclusion.

During active distraction elastic forces of II class from upper canine to lower molars region and vertical bone anchored elastic forces in the midline regions were used to decrease the load on the TMJ surfaces and for better controlling the distraction vectors. Contention time was 4 months with elastic forces application during the night followed by device removal.

Ethical approval: The research related to human use complied with all the relevant national regulations, institutional policies, and in accordance with the tenets of the Helsinki Declaration. The report was approved by the authors' institutional review board or equivalent committee.

Informed consent: Informed consent has been obtained from all individuals included in this study.

3 Results

Aesthetic results comparing Likert evaluation scores at pre-operative time, post-operative time (2 years) and score difference (Δ) between pre and post-operative time are summarized in Tables 1, 2, and 3. Large discrepancy between score results at pre-operative and post-operative times were detected in cases showing large jaw discrepancies (pronounced III and II class malocclusions) requiring double jaw surgery. Maximum Δ score between pre- and post-operative evaluation was detected in the pronounced II class cases treated by maxillary distraction plus mandibular distraction in one surgical stage followed by ancillary surgery (open rhinoplasty).

Nice aesthetic result with high-score difference (Δ) between pre- and post-operative evaluation was obtained in case 1 (Figure 1) of the upper jaw surgery (Tables 1 and 2).

In this case the distractor device was modified by a telescopic arm on the upper molars, which allowed their orthodontic distalization by coil springs and extra-oral traction (Figure 1). In this case maxillary distraction by

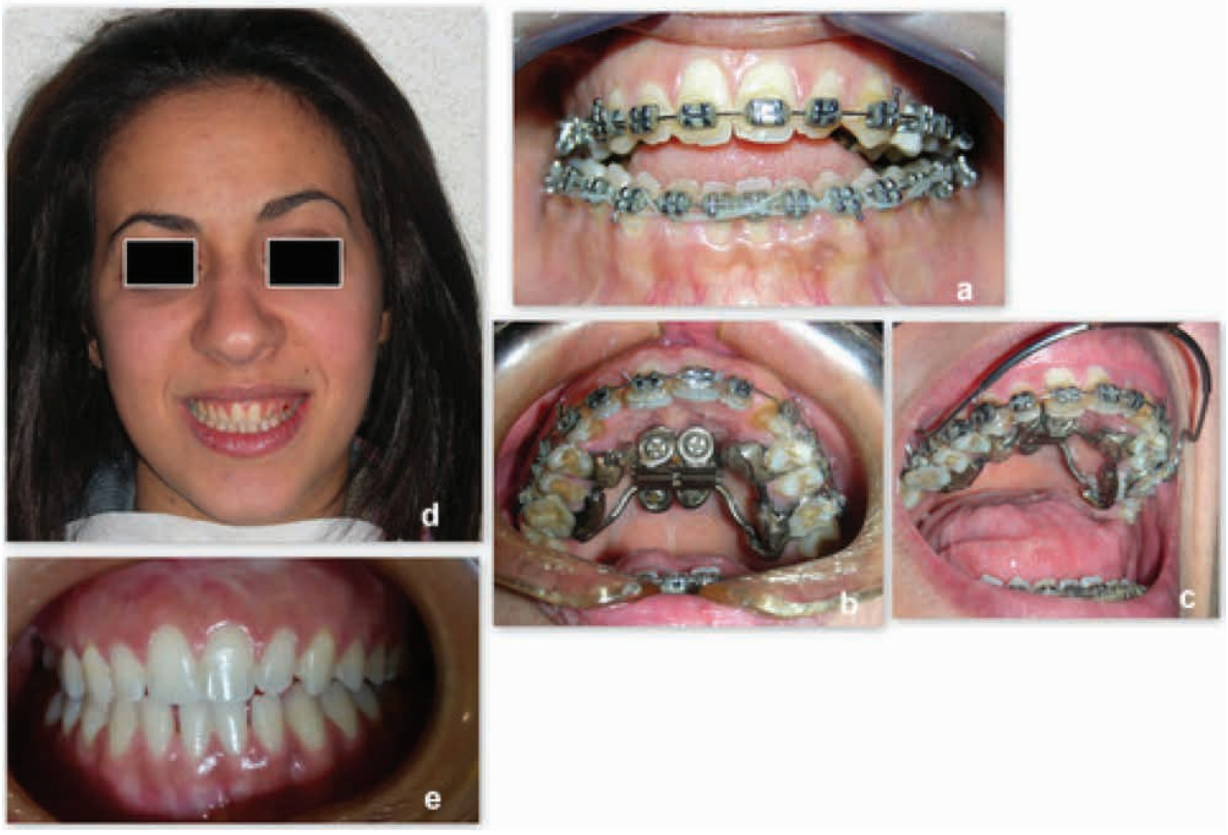

Figure 1: Case 2 a) pre-operative view showing molar cross bite and anterior open bite; b) palatal distractor fixed in paramedian site by four smart lock screws and telescopic arms on molar bands for bone anchored distalization; c) Oral view during orthodontic treatment showing extraoral traction to support molar distalization; d) Post-operative extraoral view; e) Oral view at 2 years post treatment.

Table 1: Mean aesthetic evaluation of 10 patients operated by distraction techniques selected at pre-operative, post-operative (2 years) and relative difference pre- to post-operative time following Likert scale

	Pre-operative time score	Post-operative time score (2 years)	Δ pre-post operative time score
Upper jaw surgery 7 cases	1,57	4,57	3
Lower jaw surgery 3 cases	1	4,66	3,66

Table 2: Aesthetic evaluation at upper jaw of 7 patients selected at pre-operative and 2 years post-operative time following Likert scale.

	Pre-operative time score for upper jaw surgery	Post-operative time score for upper jaw surgery (2 years)
Patient 1	1	5
Patient 2	1	4
Patient 3	1	5
Patient 4	2	5
Patient 5	2	4
Patient 6	2	4
Patient 7	2	5

Table 3: Aesthetic evaluation at lower jaw of 3 patients selected at pre-operative and post-operative (2 years) time following Likert scale.

	Pre-operative time score for lower jaw surgery	Post-operative time score (2 years) for lower jaw surgery
Patient 1	1	5
Patient 2	1	4
Patient 3	1	5

bone anchored device plus immediate maxillary repositioning following the Cortese technique was associated to bilateral sagittal split osteotomy (BSSO) for skeletal open bite closure in the same surgical stage. Four self-locking screws were adopted for palatal paramedian site bone anchorage away from dental roots area that allowed upper molar distalization by modified distracter device without any interference between molar roots and screws anchorage. In other types of bone anchored distracter devices, bone anchorage was performed in the lateral aspect of the palate with possible interferences with molar roots and related periodontal risks and the impossibility to perform contemporary molar distalization.

High Likert score was obtained also in case 2 for the upper jaw surgery (Tables 1 and 2): in this case the segmented Le Fort I osteotomy line was modified to run beneath the anterior nasal spine, leaving all perinasal muscles attached to the spine. In this way enlargement of the alar nose base or undesired main modification of the tip of the nose were avoided (Figure 1 and 2)

Nice result with high Δ score between pre-operative and post-operative aesthetic score was detected also in case 3 (Figure 3) of the upper jaw cases (Tables 1 and 2).

All the patients were fully satisfied of their functional and aesthetic results with complete acceptance of their new face aesthetic.

4 Discussion

To obtain a 3-D expansion of the two maxillary bones with full control of the movements in the three planes of the space a rigid distractor made by a titanium orthodontic jackscrew (Dentaurum gmbh & co.) casted with four one-hole miniplates for bone anchorage by four self-locking screws (Stryker) was used.

Since first cases published in 2009 by Cortese et al [34], the technique was developed by changing bone anchor site from the lateral-palate aspect to the paramedian region with the use of self-locking miniplates and screws to achieve complete rigidity of distractor device and bone anchorage complex associated with full control of the distraction vectors. Shifting bone anchorage site from lateral to paramedian palate region, several advantages have been achieved in screw insertion while avoiding risks for dental roots in the molar region and avoiding dislocation of the screws for bone thinness of the lateral palatal aspect in favor of the thicker paramedian site.

The paramedian site was suitable for screw anchorage because of sufficient bone thickness of the foot of the

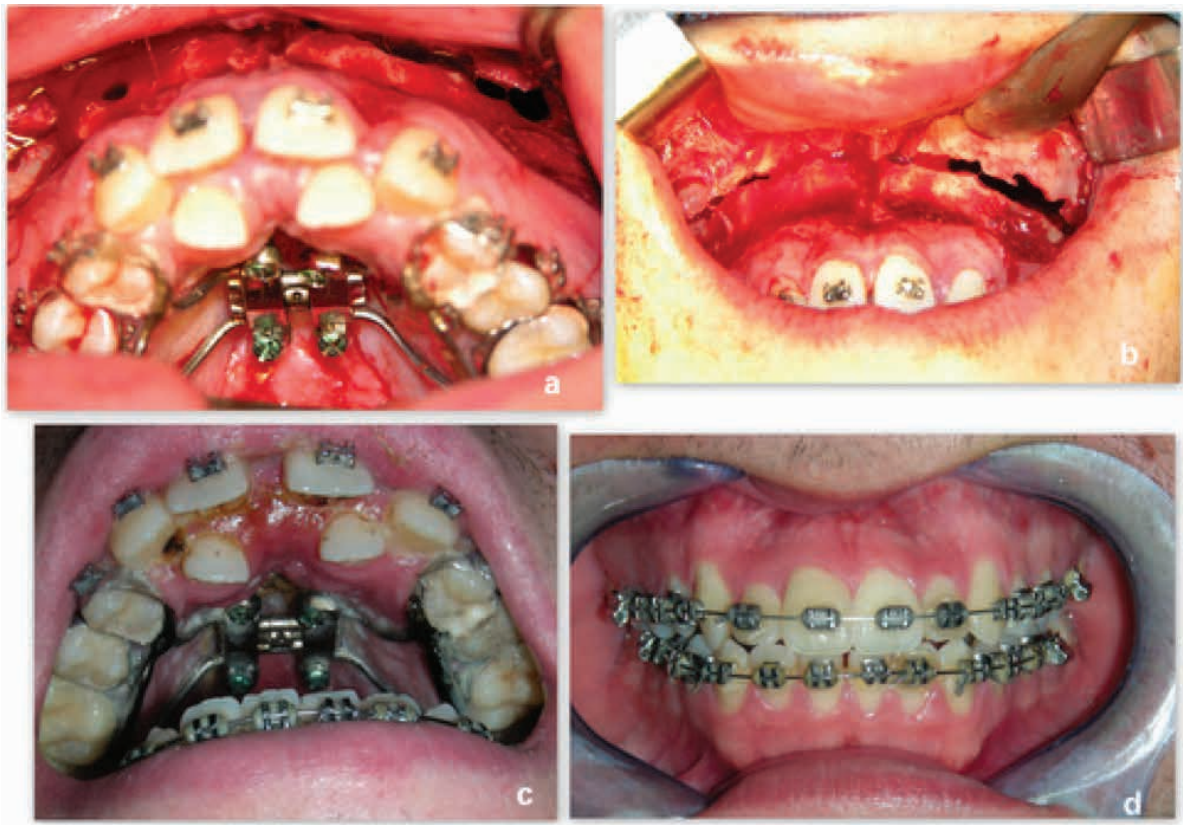

Figure 2: Case 2 of the upper jaw surgery (table 2) showing Le-Fort I modified osteotomy line conducted under the anterior nasal spine leaving attached the perinasal muscle; a) intra operative view with inserted distractor device in a paramedian site; b) modified Le Fort I osteotomy line conducted beneath the anterior nasal spine; c) intraoral view during active distraction time; d) post operative time

nasal septum to accommodate proper length screws (at least 6 mm of usable bone thickness).

Further evolution of the procedure was to adopt distractor devices with both bone and dental anchorage using four screws in the paramedian site and four orthodontic bands on first upper arch molar and premolar. In this way it was possible to obtain both a bodily movement of the maxillary bones during distraction and an orthodontic bone anchorage after distraction.

In case of bone anchorage need during post-surgical orthodontic treatment, it was possible to cut the distractor arms of the molar bands and use the premolar bands still connected to the device as a bone anchored system.

By using these kind of rigid distractors made of a jackscrew combined with a rigid bone fixation system by four self locking screws, we have been able to perform a combination of palatal distraction and maxillary repositioning in one stage.

To further obtain these results we followed the Cortese technique [34]: after a two pieces segmented Le Fort I osteotomy with down-fracture, a three dimensional repositioning of the maxillary bones was performed in one stage adopting a four L-shaped fixation system with only three screws for each miniplate leaving free the second upper hole for each miniplate. In this way it was possible to obtain a good stability of the two maxillary bones in the sagittal direction combined with sufficient flexibility in the transversal direction to allow palatal expansion during jackscrew activation.

Basically it was performed a combination of SARPE with a segmented Le Fort I osteotomy and repositioning, thereby combining advantages of both techniques and avoiding all their disadvantages.

Performing bodily expansion and repositioning of the two maxillary bones in one stage allowed us to achieve proper corrections of the occlusal discrepancies and a full satisfactory aesthetical result with full control of the distraction vectors.

Following the above-mentioned Cortese technique it was also possible to obtain optimal nasal air-way functional results, because following complete section of the septum base a sagittal midline osteotomy of the two maxillary bones was performed, therefore obtaining a palatal distraction without any nasal septum deviation.

Following a Le Fort I osteotomy line conducted beneath the anterior nasal spine it was possible to perform

Figure 3: Case 3 upper jaw surgery (table 2) a) Pre-operative oral view; b) Oral view during orthodontic treatment; c) Oral view at 2 years post treatment; d) Extraoral view at 2 years post treatment

a maxillary down-fracture leaving the nasal spine in the original position without any perinasal muscle detachment, thereby avoiding alar base nose widening.

Surgical indications for mandibular distraction are related to high-risk for condylar resorption and dysfunction in severe class II skeletal discrepancies, particularly in risky cases such as young female with thin back-tipping condyles and dolichofacial biotypes [35].

From literature consensus in cases of severe class II discrepancies, when the need for mandibular arch advancement exceeds 10 mm, traditional BSSO surgery is risky for condylar resorption and malocclusion relapse: in such cases mandibular distraction is indicated.

Because of the asset of the masticatory muscles showing all of the elevator muscle insertions on the ramus fragment and all of the depressors and retrusor muscles insertions on the mandibular arch fragment, a strong couple of forces is generated in the gonial osteotomy site. A properly built distractor device needs to oppose these forces with an unfavorable cantilever against bite forces and forward movement during distraction. In order to obtain a full control of the distraction forces and on the final movements of the anterior mandibular fragment, elastic class II forces and vertical elastics in the median mandibular region are needed.

In addition during distraction high compression forces are loaded on condylar surfaces because of the strong resistance by retrusor muscles against forward movement of the mandibular arch fragment in combination with depressor muscles resistance against counterclockwise rotation of the mandibular arch. To unload distraction forces on the condylar surfaces, the aforementioned class II elastic forces in combination with vertical elastic forces in the anterior median region on bone anchorage screws are needed.

Elastic forces were also used during contention time following active distraction, for proper bone ossification and gradual condylar loading to avoid TMJ dysfunction. During the active distraction time because of the triangular shape of the mandibular arch and consequent divergent distraction vectors, inter-condylar distance enlargement occurred with associated TMJ pain. In this event we stopped active distraction, and after inter-maxillary wiring, release of the distraction device connections to the bone anchorage pills was performed. In this way condylar heads were free to reseat in the condylar fossae decreasing

TMJ pain. At this time distraction device anchorage was locked, inter-maxillary fixation was removed and active distraction restarted up to the final amount of needed advancement. Advantage of this technique is associated to regular contouring of the lower border of the mandibular arch because the osteotomy site is performed at the pre-gonial incisure thereby resulting in nice contouring and evidence of active regeneration of the mandibular border at the osteotomy gap both for soft and hard tissue during distraction probably due to stem cells activation at that site. Furthermore advantage of this technique is related to the ability of the clinician to monitor accomplished movements and results during distraction while avoiding condylar sag problems frequently associated to conventional BSSO surgical techniques.

5 Conclusion

Aesthetic result in all patients was highly satisfactory. The result was quite natural and the patients accepted the new aesthetic of their face avoiding elements of discrepancy and consequently medico-legal problems. These kinds of problems occur when the size of the facial skeleton has been reduced by conventional surgery and the new identity is not recognized and accepted by the patients. Our goal has been to achieve the best aesthetic and functional results by distraction and new techniques [36,37]; in this way patients achieved full satisfactory results and accepted the new aesthetic of their face and subconscious new identity.

This kind of planning, aimed to obtain maximum skin tension by skeleton enlargement and harmonization may also prevent facial decay in aging faces.

Conflicts of interest disclosures: The authors declare no conflicts of interest.

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