Mandibular Widening by Distraction Osteogenesis

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Distraction osteogenesis is a simple osteotomy procedure and gradual distraction of callus that results in an increase in bone. Multiple variables (biological, technical, and mechanical) interact in the healing process, and the controlled bone growth can also stimulate other tissues such as vessels, nerves, skin, and muscles, producing a general distraction histogenesis.

In 1905, Codivilla first reported the use of osseous distraction to lengthen a femur immediately after a fracture.[1] Abbott described lengthening of the tibia in 1927.[2] In 1978, Wagner reported limb lengthening by sporadic distraction.[3] Ilizarov began his long investigation into the clinical, bioengineering, and basic science aspects of traumatology and orthopedics, utilizing canine long bone, in the early 1950s.[4] These endeavors led to the discovery of general principles governing the stimulation of tissue growth and regeneration during distraction.

Ilizarov was the first to design a scientific protocol for bone lengthening. In 1969, he demonstrated that gradual traction on living tissues created stress that could stimulate and maintain the regeneration and active growth of certain tissue structures.[5] He called this principle the Law of Tension-Stress.[6,7] In subsequent studies, he showed that tissues subjected to slow, steady traction became metabolically activated, with the stimulation of both proliferative and biosynthetic cellular functions. Ilizarov noted that the quality of newly formed bone depended on a number of factors:

1. The rigidity of bone fragment fixation.
2. The degree of damage at the time of the osteotomy to the bone marrow, the periosteal soft tissues, the nutrient artery, and the braches.
3. The rate (speed) of distraction.
4. The rhythm (frequency) of distraction.

Most recently, De Bastiani and colleagues have made bone lengthening in the upper and lower extremities by gradual distraction a medical reality for patients with nonunion and osseous defects.[8] Other investigators have successfully repeated Ilizarov's experiments, producing as much as 20cm of vertical augmentation in the arms and legs, and some have used these methods in patients with osteomyelitis, when the only alternative would have been amputation.

In the 1970s, Snyder and colleagues[9] and Michieli and Miotti[10] first demonstrated the capability of osseous lengthening by gradual distraction in the membranous bone of canine mandibles. They fabricated a toothborne apparatus to distract and later stabilize the mandibular seg-

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ments, showing the anchorage potential of the mandibular teeth. In 1990, Karp and colleagues confirmed the feasibility of canine mandibular lengthening via extraoral distraction, with minimal morbidity.[11] Later that year, they documented cortical bone formation in the expanded areas of the mandibles with radiographic, histologic, and vital dye studies.

Bell and Epker described in 1976 a technique for surgically assisted rapid palatal expansion to increase maxillary arch width in adults with transverse deficiencies.[12] Their jackscrew appliance was soldered to bands on the maxillary first premolars and first molars. The maxilla was mobilized by lateral osteotomies, pterygomaxillary dysjunction, minimal downfracture of the maxillary segments, and a vertical osteotomy in the midline. The appliance was activated to the point where blanching of the gingival soft tissues was evident adjacent to the distraction site, then reactivated about 1mm every other day.

Because the anterior mandible finishes its transverse growth at an early age, orthodontic expansion of the mandibular arch has traditionally been accomplished by alveolar remodeling and buccal tipping of the teeth, rather than by true skeletal mandibular widening. In other words, maxillary expansion has been limited by mandibular arch width. In 1990, however, Guerrero applied mandibular distraction osteogenesis in 11 patients with transverse mandibular deficiencies, using the principles advocated by Ilizarov, with custom-made intraoral jackscrews.[13] Guerrero waited about seven days after surgery before distracting at a rate of 1mm per day, then maintained the expansion with the appliance for two months. Anterior crowding was corrected, and the expansion of 4-7mm was stable, without temporomandibular joint dysfunction, periodontal problems, or malunions.

Guerrero, Contasti, and colleagues have described in detail the indications and orthodontic principles of mandibular widening.[14-19] Other clinicians have used mandibular widening by distraction osteogenesis with stable and predictable results.[20-25] Today, mandibular transverse deficiency is a skeletal deformity with a predictable treatment solution—surgically assisted expansion by distraction osteogenesis—without the need for extractions or compromised esthetic, functional, or periodontal results.

Diagnosis and Treatment Planning

The most common clinical indications for successful mandibular expansion treatment are:

- V-shape mandible.
- Severe mandibular crowding with well-aligned maxillary teeth.
- Brody's syndrome ("scissor bite", uni- or bilateral).
- Impacted anterior mandibular teeth with no available space.
- Maxillomandibular transverse deficiency ("crocodile bite", "tunnel smile").
- Retreatment with crowding (with or without extractions).

Early identification of transverse discrepancies is necessary for optimum skeletal arch expansion. Although most clinicians do examine the transverse relationship intraorally, a clinical examination will not identify skeletal discrepancies, because of dentoalveolar compensations.

Three-dimensional data obtained from study casts can be converted into two-dimensional data for analysis by occlusogram. First, the ideal maxillary archform is traced. The transverse arch dimension is determined by measuring the intercanine and intermolar distances on the casts and transferring the measurements to the tracings. The shape of each mandibular tooth can then be traced in the ideal position in relation to each maxillary tooth. At this point, the clinician can measure the transverse discrepancy by superimposing the idealized mandibular archform over the original mandibular archform.

The Ricketts postero-anterior cephalometric analysis is another useful tool because it provides the real skeletal transverse discrepancy within each arch, especially the difference between JL-JR and AG-GA. Measurements such as A6-6A/B6-6B/B3-3B indicate whether the transverse problems are due to tooth inclinations or skeletal deficiencies.[26]

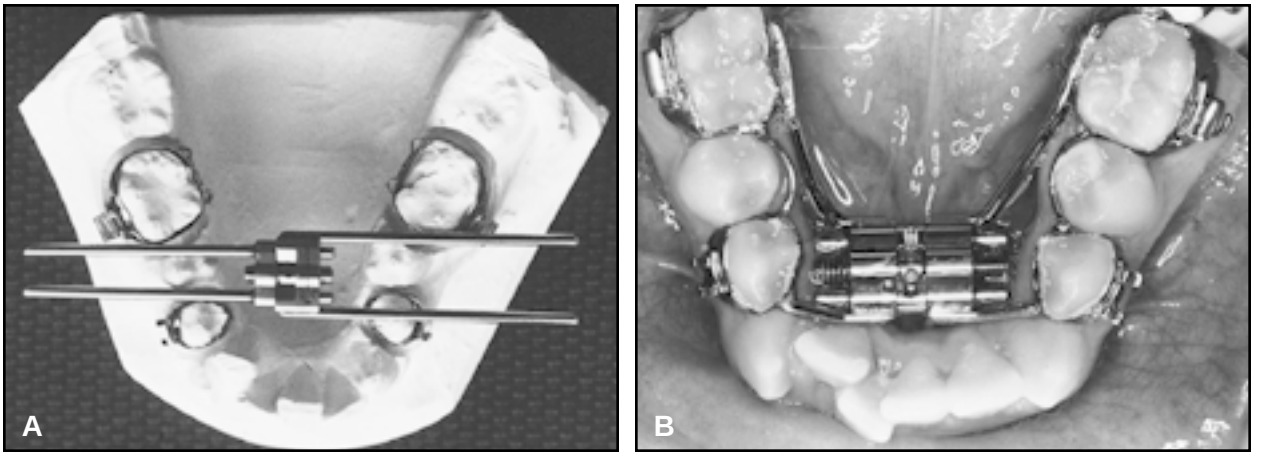

Fig. 1 Construction and insertion of mandibular distractor appliance.

Failure to plan adequately for maxillomandibular transverse discrepancies may lead to post-treatment instability and relapse. Possible treatment plans for skeletal transverse discrepancies include:

- Orthopedic palatal expansion appliances in growing patients.
- Orthopedic mandibular expansion with a variety of appliances in the early mixed dentition.
- Surgically assisted maxillomandibular widening in young adults or older patients. Such correction has the advantage of enhancing esthetics by promoting greater dental arch visibility in the buccal corridors. The periodontal status may also be improved when skeletal transverse discrepancies are addressed surgically, rather than solely by orthodontic means, because dental expansion can promote a thinning of the buccal cortical bone with concomitant gingival recession and dental instability.
- Correction of anterior mandibular crowding by surgical mid-symphysis mandibular expansion in young adults or older patients. This will improve dental alignment without the need for extractions and can reshape narrow arches into wider ones.

Presurgical Orthodontic Management

The maxillary arch will often have transverse dental compensations or mild crowding with poor archform that must be corrected before the mandibular expansion. Maxillary bands and brackets must therefore be placed initially to level and align, correct axial inclinations, and coordinate the maxillary arch. A surgical rectangular arch is then placed before fabrication of the mandibular distractor appliance.

Separators are placed mesial and distal to the mandibular teeth that will support the distractor (usually the first molars and first premolars). After one week, bands are fitted, and an impression is made. The bands are carefully removed from the teeth and set into the impression, and a working cast is poured (Fig. 1A).

The appliance consists of four bands, an expansion screw (generally 7-11mm) with four .060" stainless steel arms welded to the screw and to the bands, and another .036" stainless steel wire connecting the two bands on each side for stabilization. The expansion screw must be placed as anteriorly and inferiorly as the arch configuration will permit, without impinging on the gingiva or mucosa or interfering with the ability to turn the screw (Fig. 1B).

Once the appliance has been fabricated and the surgery scheduled for one or two days later, the screw is cemented in place, but not activated. The screw must be cemented strongly enough that it will not become loose or displaced during the mandibular expansion.

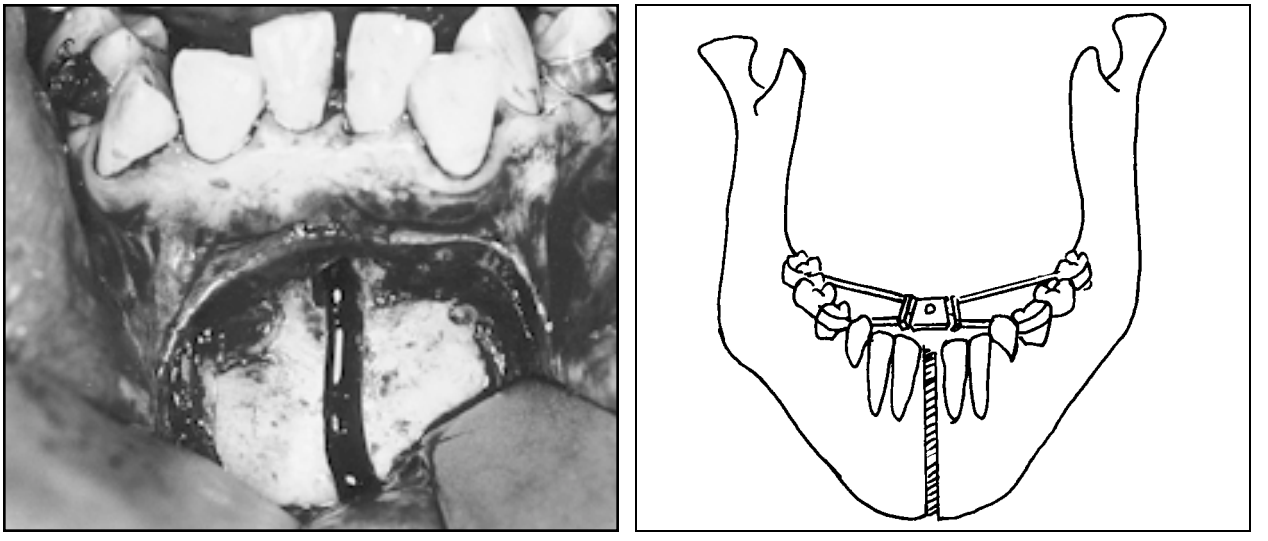

Fig. 2 Mandibular symphyseal osteotomy.

Surgical Technique for Symphyseal Osteotomy

The incision is made 4-6mm labial to the depth of the mandibular vestibule, through the orbicularis oris muscle (Fig. 2). After the muscle is transected, the dissection is directed obliquely, posteriorly, and inferiorly through the mentalis muscle until contact is made with the mandibular symphysis. The periosteum is reflected inferiorly to the lower border of the mandible, where a channel retractor is placed. It is important to keep the periosteum carefully elevated and meticulously separated throughout the whole procedure, because most of the healing capacity comes from the periosteum. Next, the soft tissue between the mandibular central incisors is carefully reflected superiorly to the alveolar crest, with minimal detachment of the neighboring tissues. A skin hook is used to reflect the flap superiorly.

A vertical osteotomy is made through the symphyseal area with an oscillating saw blade, starting at the inferior border of the mandible and extending to the interdental space between the apices of the mandibular central incisors. Then, with a straight handpiece and a surgical No. 701 bur, the cut is continued on the labial cortical plate of the mandible until the alveolar crest is reached. The final sectioning is done manually with a mallet and spatula osteotome. Excessive pressure on the mandible should be avoided to prevent displacement of the expansion appliance. The forefinger should be used as a guide at all times to avoid tearing of the lingual soft tissue.

Once the vertical osteotomy and sectioning of the mandible have been completed, a guide pin is inserted into the jackscrew appliance. It is carefully activated to corroborate a complete osteotomy and then closed back to 0mm. A security thread is attached to the pin to avoid inadvertent displacement. Wounds must be sutured in proper tissue planes, with special attention to the periosteum.

Post-Surgical Orthodontics

The most important post-surgical orthodontic considerations are:

- Waiting seven days before activation of the device to ensure good collagen fiber formation at the distraction site.
- Complete activation of the orthopedic expansion appliance to produce gradual bone growth.
- Stabilization of the expansion appliance.
- Application of a force system to coordinate both arches into a Class I relationship.
- Gradual closure of the midline diastema.
- Proper finishing.
- Retention.

After the latency period of seven to 10 days, the distractor is activated 1mm per day, and the patient is seen regularly until the desired mandibular expansion has been completed. At this point, the appliance is stabilized by covering the screw with acrylic, and the patient can re-

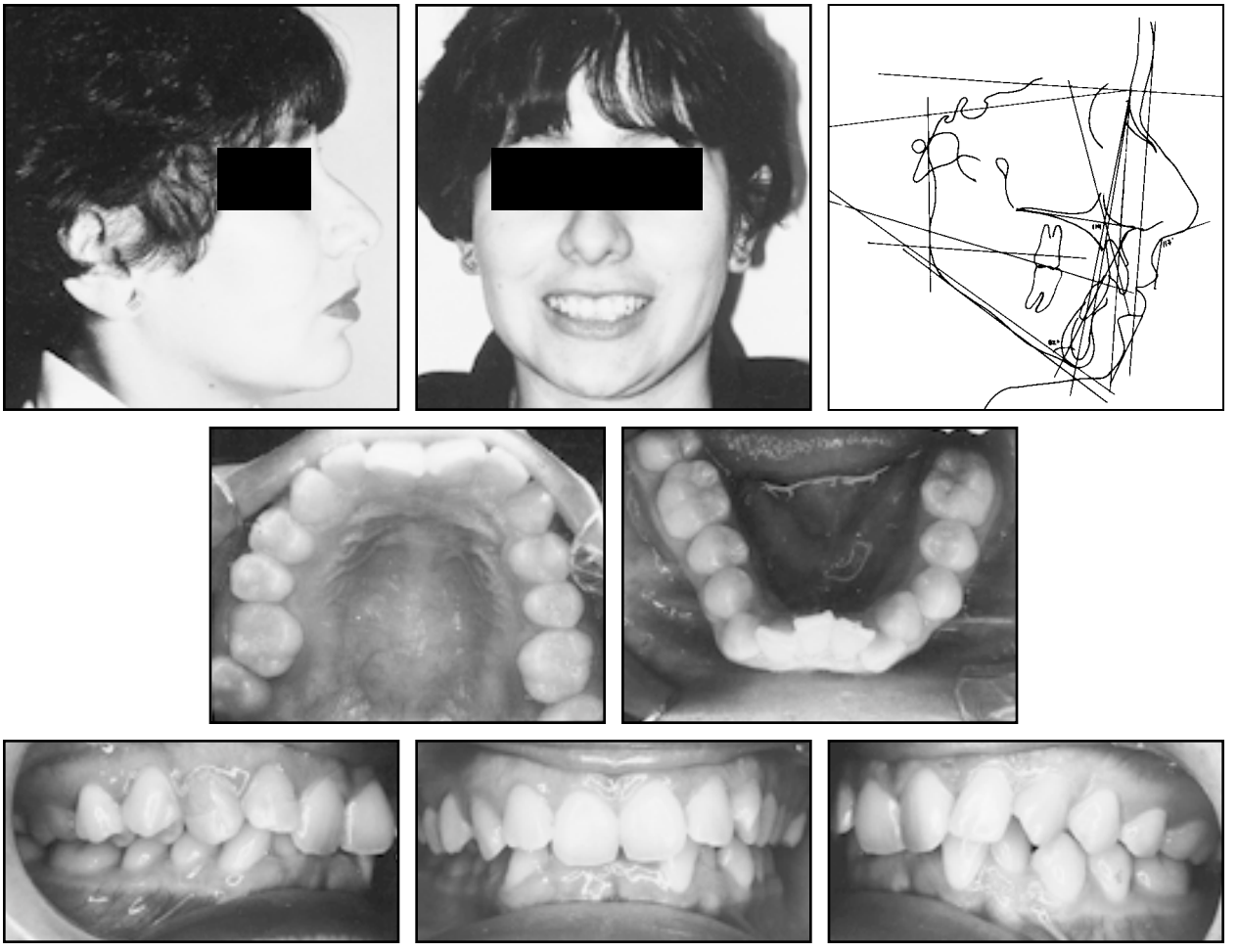

Fig. 3 Case 1. Adult female with Class I malocclusion, deep bite, mild maxillary crowding, severe mandibular crowding, and right posterior buccal crossbite. Obtuse nasolabial angle precluded maxillary extractions and any retraction of upper lip.

sume a soft diet.

Because an anterior diastema is produced by the expansion in the osteotomy area, a plastic pontic with a bonded bracket can be placed to maintain arch length, keep the teeth from prematurely drifting mesially, preserve periodontal health, and provide optimal esthetics. All the anterior teeth can be bonded two weeks after surgery, but no attempt should be made to close the diastema until the distractor is removed two months later.

Once the orthopedic appliance has been removed, a full fixed appliance is bonded, and a round stainless steel archwire is placed, as stiff as the malocclusion will permit. Light interdental forces are applied along the round wire until the diastema is totally closed, with the pontic progressively trimmed mesiodistally. We highly recommend placing an .036" stainless steel lingual arch at this point to retain the expansion. Leveling and alignment, arch coordination, finishing, and retention are carried out as usual.

Case 1

An adult female patient presented with a Class I molar relationship with mild maxillary crowding, a severe deep bite, a curve of Spee of +3mm, severe mandibular crowding (7mm), an adequate Bolton tooth-size relationship, and a right posterior buccal crossbite (Fig. 3). The lateral cephalogram showed an obtuse nasolabial angle of 117°.

When mandibular crowding is significant

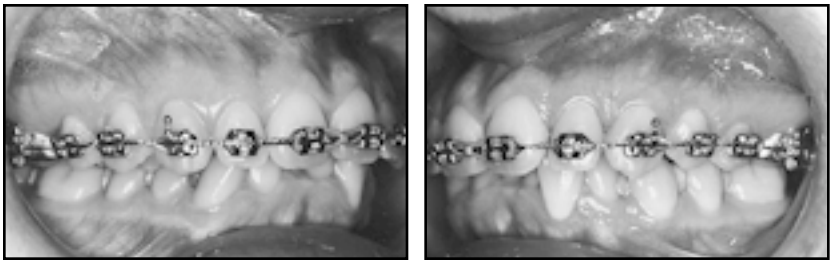

Fig. 4 Case 1. Presurgical preparation of maxillary arch.

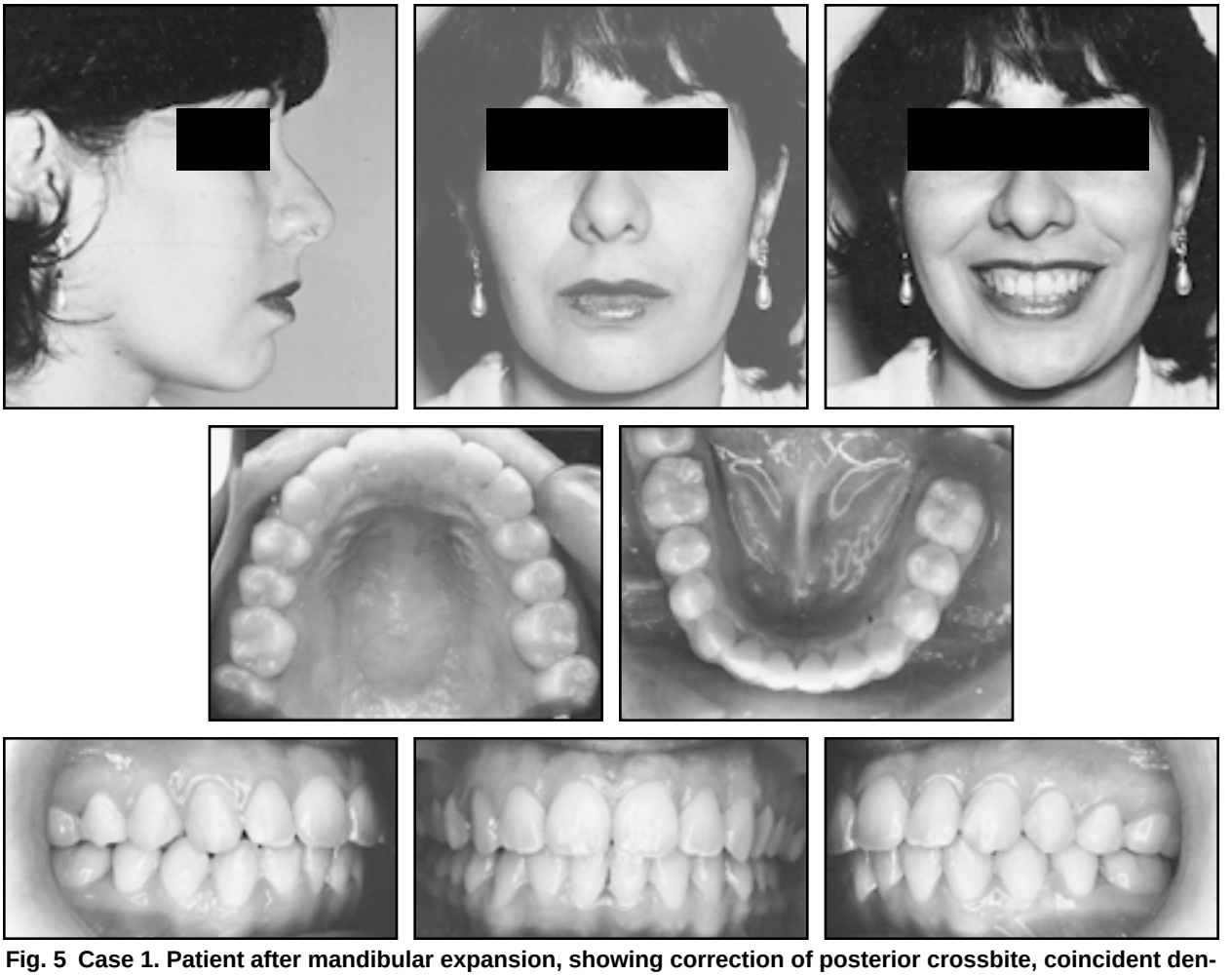

Fig. 5 Case 1. Patient after mandibular expansion, showing correction of posterior crossbite, coincident dental midlines, and good overjet and overbite.

Fig. 6 Case 1. Panoramic radiographs taken immediately after surgery and after orthodontic treatment, showing bone fill in distraction site.

enough to indicate extractions, the maxillary arch is usually planned for extractions as well. In this case, however, extractions were contraindicated by the obtuse nasolabial angle in an adult female with only mild maxillary crowding.

The maxillary arch was completely prepared, and a surgical rectangular archwire was placed (Fig. 4). Nothing was done in the mandibular arch before placement of the distractor to avoid unwanted proclinations or bone loss.

The toothborne appliance was fabricated and installed one week prior to surgery. The vertical osteotomy was performed between the two central incisors, producing an opening of 7mm at the distraction site.

Leveling and alignment were easily completed without the need for extractions or interproximal stripping, and a good Class I occlusion was achieved (Fig. 5). From the periodontal point of view, no retractions, dehiscences, pockets, or keratinized attached papillae were found.

Panoramic radiographs taken immediately after surgery and two months later, prior to removal of the distractor, showed the bone completely healed (Fig. 6).

Case 2

A 25-year-old female patient presented with a Class I malocclusion (Fig. 7). She had narrow, V-shape arches, an open bite, mild maxillary crowding (4mm), and severe mandibular crowding (7mm).

Treatment was planned to simultaneously widen the maxilla and the mandible and thus obtain enough space to correct the crowding and close the open bite. Four-bicuspid-extraction treatment was ruled out by the narrow arches and "tunnel smile".

No fixed orthodontic appliances were used before fabrication and placement of the upper and lower toothborne distractors (Fig. 8). A Le Fort I to intrude 3mm vertically and to widen the maxilla was done at the same time as the mandibular vertical osteotomy, which was performed between the right central and lateral incisors due to better space availability. Openings of 7mm were obtained in both arches.

After the stabilization period, closure of the diastemas, leveling, alignment, and finishing were managed as in any orthodontic case. The Class I occlusion was maintained, the open bite

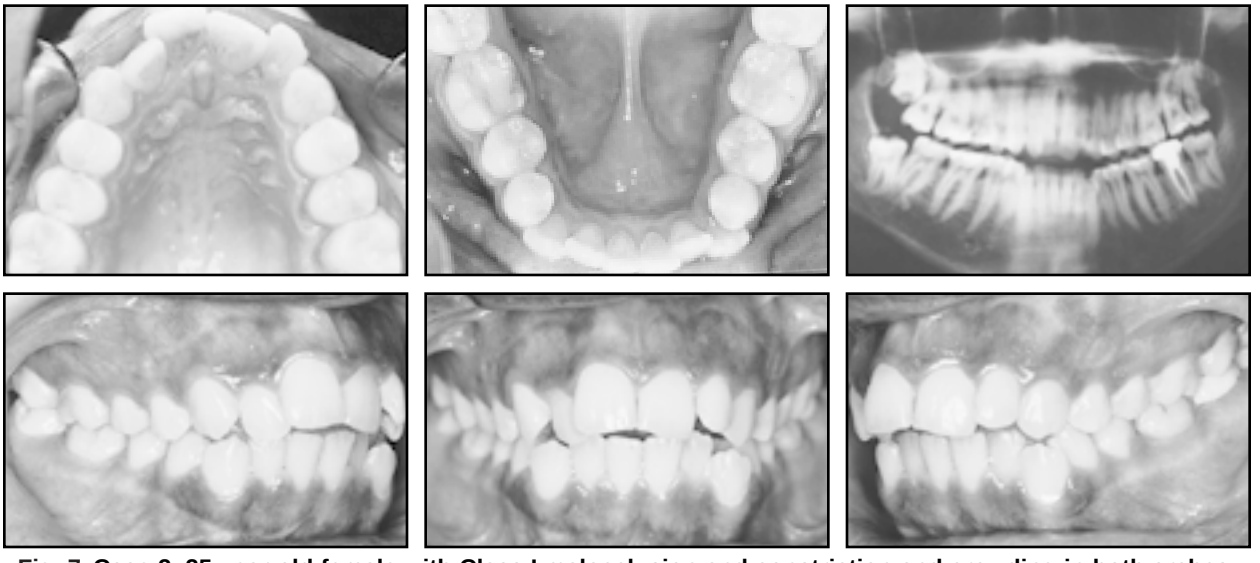

Fig. 7 Case 2. 25-year-old female with Class I malocclusion and constriction and crowding in both arches.

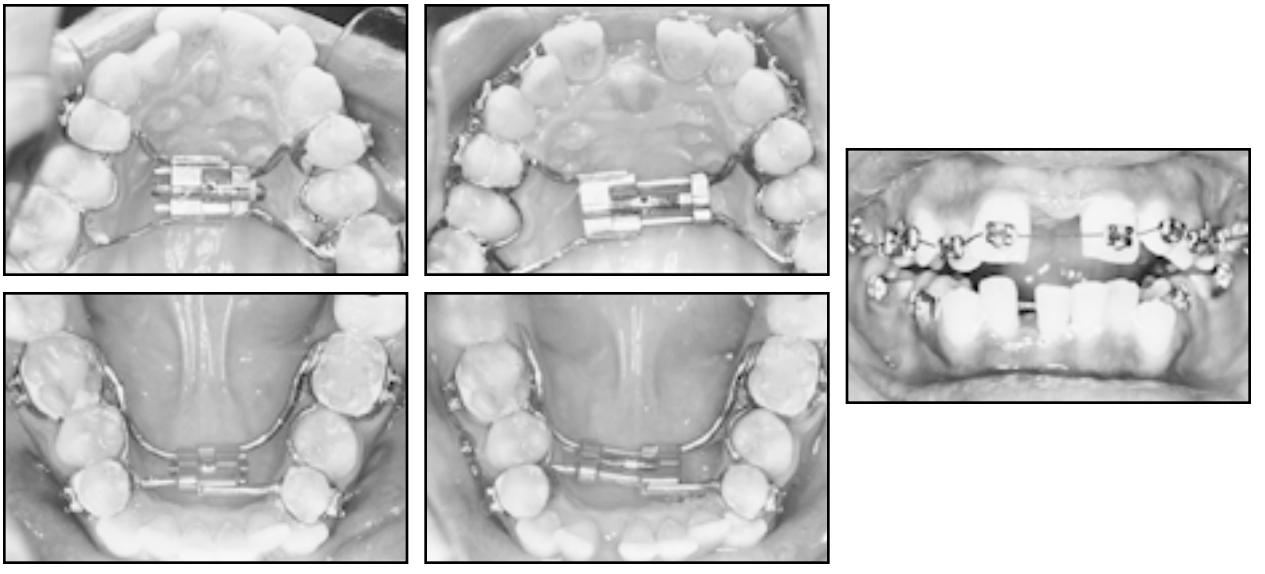

Fig. 8 Case 2. Before and after surgically assisted expansion.

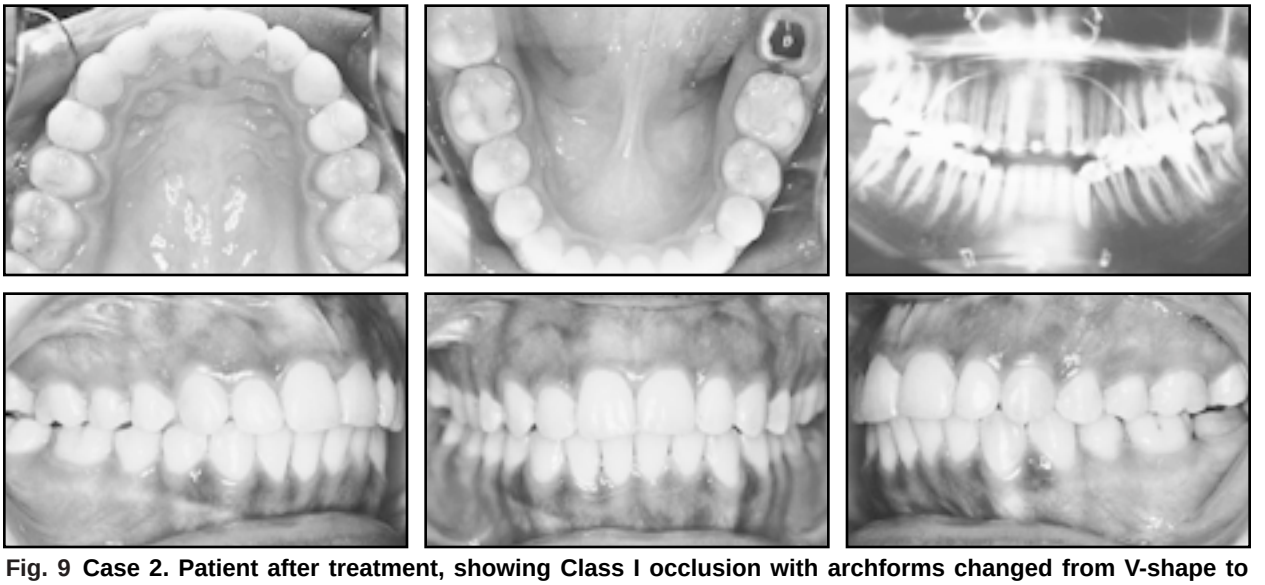

Fig. 9 Case 2. Patient after treatment, showing Class I occlusion with archforms changed from V-shape to more normal U-shape. Panoramic radiograph after maxillomandibular expansion shows good bone healing in osteotomy site.

was closed, and the crowding was resolved without compromising the alveolar bone, attached papillae, or intercuspid arch dimensions (Fig. 9). The frontal view of the patient's smile indicated a widening of the transverse dimension and elimination of the black lateral tunnels. Panoramic radiographs showed good healing at the osteotomy site.

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