COMBINATION SYNDROME: CLASSIFICATION AND CASE REPORT

Len Tolstunov, DDS

Combination syndrome (CS) is a dental condition that is commonly seen in patients with a completely edentulous maxilla and partially edentulous mandible with preserved anterior teeth. This syndrome consists of severe anterior maxillary resorption combined with hypertrophic and atrophic changes in different quadrants of maxilla and mandible. This makes it a challenging condition in dentistry that requires significant experience along with advanced restorative and surgical skills. The causes of maxillary bone resorption and ways to correct it are discussed in this article. Conventional treatment with full upper and partial lower dentures for the CS patients is not always adequate or satisfying for patients and it often requires multiple remakes due to continuing bone resorption. Dental implant rehabilitation challenges conventional treatment with bone-anchoring techniques to provide improved retention and stability for implant-retained and supported prostheses. This article presents a successful implant treatment of the partially edentulous maxilla in CS patient. The author proposes a new classification of the combination syndrome that includes a multitude of CS cases with partial and complete maxillary and mandibular edentulism. The necessity of a multi-disciplinary approach for early prevention and treatment of this complex condition is emphasized.

Key Words: resorbed maxilla, hypertrophic bone, atrophic bone, teeth super-eruption

INTRODUCTION

Combination syndrome (CS) is defined as "a condition caused by the presence of the lower anterior teeth and the absence of the posteriors and resulting in significant maxillary anterior alveolar resorption."[1] This condition often develops in cases of a complete maxillary denture opposing a bilateral distal extension mandibular partial denture[2] (Figures 1 through 3). The resulting chronic occlusal trauma from the mandibular anterior teeth to the premaxillary hard and soft tissue structures often leads to a slow resorption of the anterior maxillary alveolar ridge that is replaced with the fibrous tissue. Ellsworth Kelly followed up 6 patients for 3 years with a complete maxillary denture opposed by mandibular anterior teeth and a distal extension removable partial denture (RPD).[3] Kelly gave the name "combination syndrome" to this condition. He described 3 key features of CS: reduction of anterior maxillary bone, enlargement of maxillary tuberosities, and bone resorption under the mandibular RPD bases. A lack of posterior occlusion and the presence of excessive anterior occlusal function by super-erupted anterior mandibular teeth led to the use of another name for this condition, "an anterior hyperfunction syndrome."[2] Other features that may be present at the same time include loss of vertical dimension of occlusion, occlusal plane discrepancy, anterior spacial reposition of the mandible, poor adaptation of the prosthesis, and others.[4,5] Prevention of loss of posterior occlusion and avoidance of anterior hyperfunction are considered the main treatment approaches of this complex condition. An implant-based reconstruction of the mandibular arch with implant stabilization of the maxillary arch[6] is a modern bi-maxillary surgical-prosthetic therapy for many CS cases.

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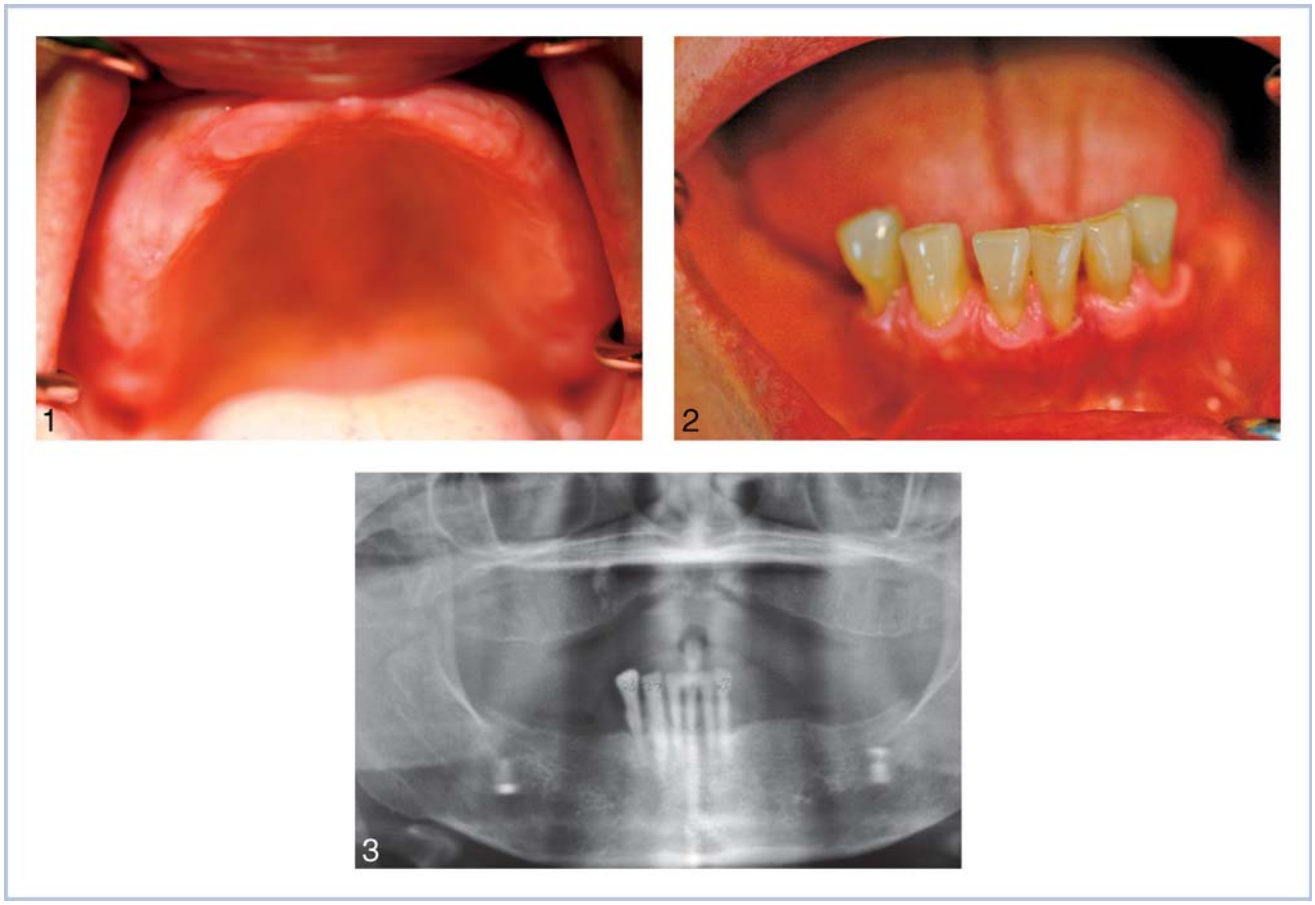
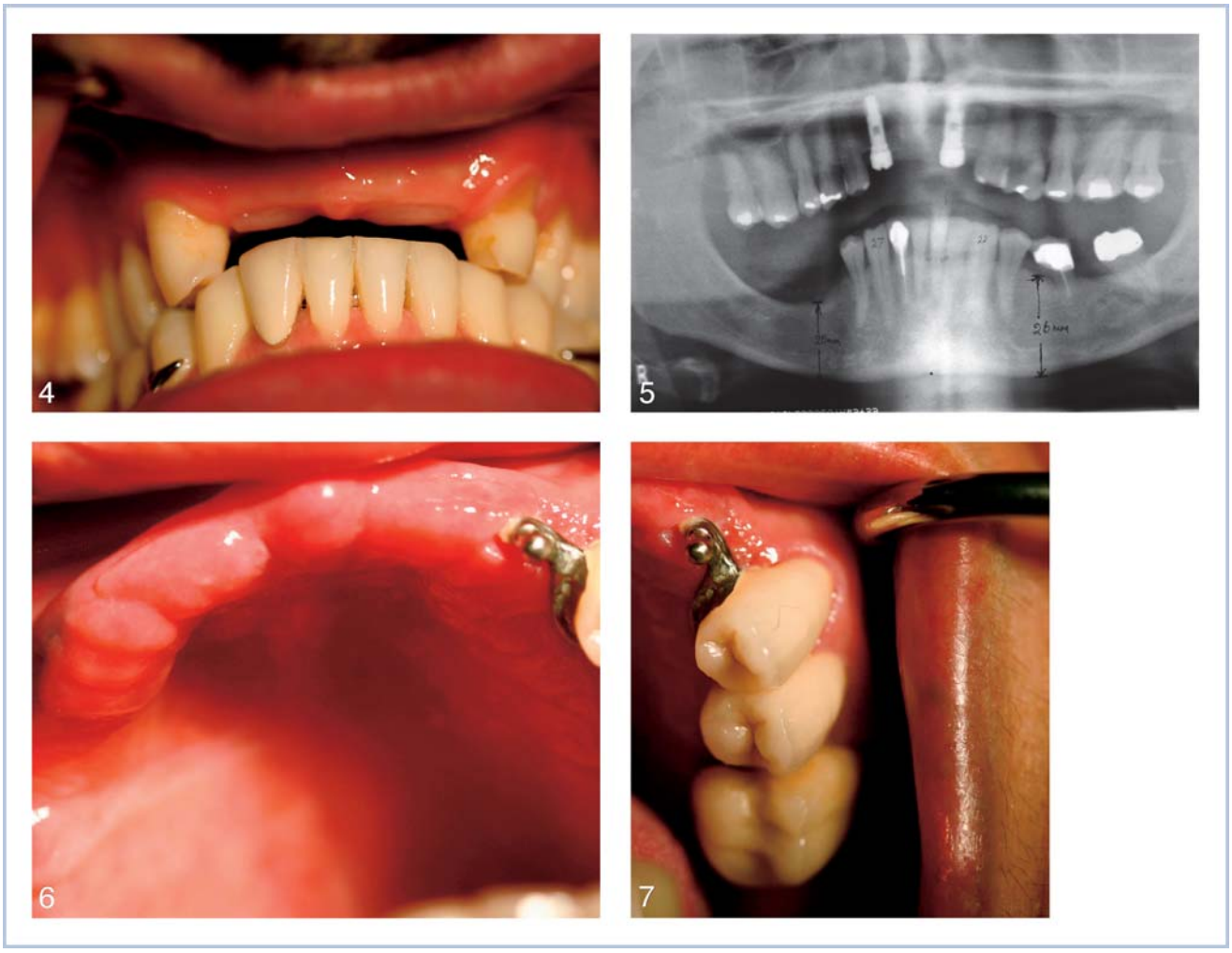


FIGURE 1–3. Typical case of the combination syndrome patient with a complete edentulous maxilla opposed by the anterior mandibular teeth and a distal-extension removable partial denture: a severe resorption of the anterior maxillary alveolar ridge, super-eruption of unopposed 6 mandibular anterior teeth, and overgrowth of maxillary tuberosities. Combination syndrome classification: Class I, Mod. 1 (I-1).

Severe maxillary resorption is a dominant feature of combination syndrome patients. These CS patients as well as many other clinical cases of extensive three-dimensional maxillary bone loss have guided dental clinicians and surgeons towards the development of many innovative surgical and prosthetic techniques of correction of maxillary bone atrophy combined with immediate or delayed placement of dental implants. These reconstructive approaches for the compromised maxillary bone include vertical alveolar distraction osteogenesis,[7,8] horizontal distraction in combination with bilateral sinus lift/bone grafting procedure,[9,10] maxillary ridge-splitting techniques followed by immediate dental implants,[11] autogenous iliac crest[12] and calvarial bone grafting,[13] reconstruction of the resorbed edentulous maxilla with autogenous rib grafts,[14] tibial grafting for maxillary bone loss,[15] treatment of severe maxillary atrophy with vascularized free fibula flap in combination with dental implants,[16] interpositional bone grafting with LeFort I osteotomy,[17] orthognathic surgery with or without onlay bone grafting,[18,19] use of the osseoinductive effect of bone morphogenic protein within endosseous dental implants placed in the maxilla,[20] zygomatic implants with or without sinus lift/bone graft,[21,22] pterygomaxillary implants combined with zygomatic and conventional implants,[23] the Marius implant bridge for the surgical-prosthetic rehabilitation of the resorbed completely edentulous maxilla with 6 implants,[24] "all-on-4" maxillary edentulous rehabilitation with 4 strategically placed and immediately loaded implants,[25] combination of short implants and osteotome technique for the posterior maxilla,[26] use of transitional implants and bone grafting before placement of definitive implants,[27] optimal use of the anatomic features of the maxillary arch with tilted implants,[28] use of transmandibular implant[29] and Tatum custom ramus frame implant in CS patients,[30] and others.

In typical CS cases, a maxillary ridge is completely edentulous. However, patients with a partial maxillary



FIGURES 4–7. FIGURES 4 and 5. Combination syndrome (CS) case of partially edentulous maxilla and mandible: unopposed mandibular anterior teeth are super-erupted towards the atrophic premaxillary bone. Panoramic radiograph showing the bone remodeling changes of the alveolar process common for CS: resorption of anterior maxilla (treated with 2 endosseous implants) and right posterior mandible. A bone atrophy of the left mandible and a bone hypertrophy of the left maxilla are mild due to preserved teeth in a stable occlusal relationship. A bone atrophy of the right mandible and a bone hypertrophy of the right maxilla (with teeth extrusion) are pronounced due to lack of mandibular posterior teeth and posterior occlusion (occlusal pairing). Measurements of the mandibular body height from the alveolar crest to the inferior border of the mandible on equal distances from the midline at the first molar position: 26 mm (taken as 100%) on the left and 20 mm (relative 20% bone height reduction) on the right due to CS-associated atrophic changes. The patient has been wearing upper and lower removable partial dentures for the past 25 years. CS classification: Class II, Mod. 3 (II-3). FIGURE 6. Thin and resorbed anterior maxillary ridge with mobile hypertrophic tissue and papillary hyperplasia of the alveolar mucosa. FIGURE 7. O-ring attachment on the mesial extension of the No. 12-13-14 PFM bridge.

edentulism can also have similar signs and symptoms. Cases of maxillary RPD with an anterior edentulous space and preserved posterior teeth opposed by mandibular anterior teeth and a distal extension RPD or natural mandibular dentition demonstrate analogous deteriorating effects of CS. It appears that when the posterior maxillary teeth present on one or both sides and opposed by the posterior mandibular teeth, the hypertrophic changes (overgrowth) of the posterior maxilla and maxillary tuberosities are not prevalent or do not develop at all. Due to preservation of the posterior occlusal relationship, the anatomy of posterior quadrants of both jaws is not altered significantly in these cases (Figures 4 and 5). In Figures 4 and 5, the hypertrophic changes on the right posterior maxilla and super-eruption of unopposed posterior molars are more pronounced than the changes on the left side, where the posterior occlusal relationships between periodontally healthy upper and lower teeth remain.

Both implant-retained and implant-supported prostheses have become an increasingly popular and

successful prosthetic rehabilitation for partially and fully edentulous maxilla.[31,32] This case report demonstrates an implant treatment of the partially edentulous maxilla with bilaterally preserved posterior teeth opposed by a fixed crown and bridge mandibular dentition in the patient with typical features of CS. Dental implants together with natural teeth were used for retention of an implant-assisted maxillary overdenture. A new classification of combination syndrome is proposed in this article following the case report.

CASE REPORT

A 76-year-old woman with Sjogren syndrome presented complaining of a poor fit of an upper denture and difficulty chewing and speaking clearly. Patient had Sjogren syndrome for the previous 20 years in a mild and controlled form. She had been using water to compensate for dryness of her mouth and was taking prednisone 10 mg every other day for the last 2 years. Otherwise, patient's medical history was not contributory.

The patient lost some of her upper front teeth about 50 years ago and had a bridge, but eventually lost her remaining upper front teeth requiring a partial denture. She has had 2 sets of dentures for her upper jaw for the past 15 years with the second one constructed less than a year prior to her implant consultation. Patient was wearing a removable maxillary partial denture retained by the bridge No. 12-13-14 on the left side and tooth No. 2 on the right. Due to recent mobility of her upper right second molar (No. 2), her new partial denture became loose and difficult to wear. She had a previous experience with a blade implant for her lower jaw, was satisfied with it and now was interested in exploring an implant treatment for her upper jaw.

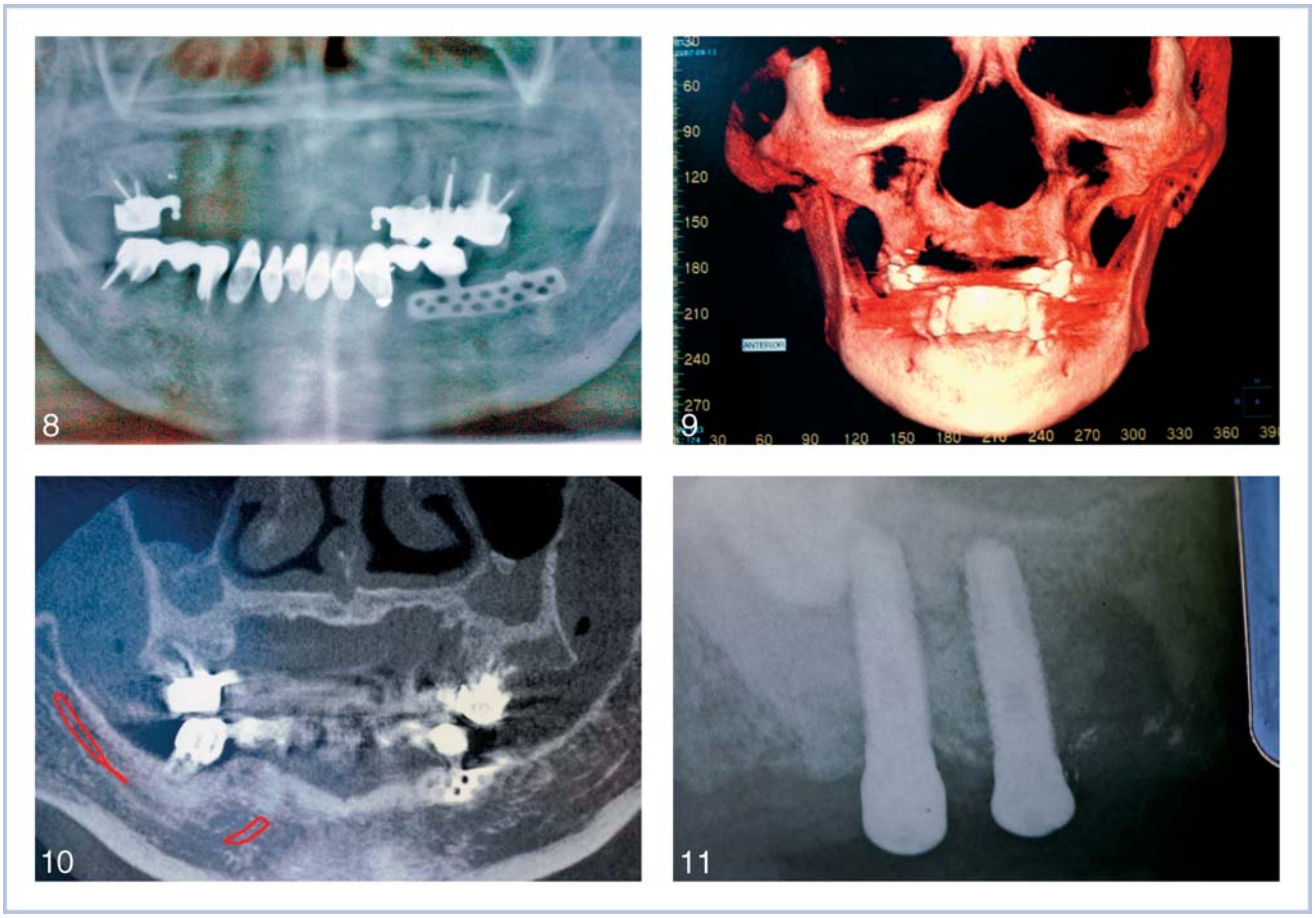
On examination, the patient presented with the maxillary RPD for the anterior edentulous area crossing the midline and bounded by the presence of posterior molars, severe maxillary bone deficiency especially in the premaxillary area, and prognathic appearing mandible (pseudo class III jaw relationship). The anterior maxillary alveolar process was thin and deficient three-dimensionally with mobile hypertrophic tissue in place of the anterior alveolar crest and papillary hyperplasia of the hard palate's mucosa (Figure 6). The patient had 4 remaining upper posterior teeth: No. 2 (mobility three plus) and No. 12, No. 13, and No. 14 (stable with recently placed crowns connected in the bridge). The crown No. 2 and the bridge No. 12-13-14 had O-ring attachments on the mesial end of both restorations for retention of patient's upper partial denture (Figure 7). In the lower jaw, the patient had an old (20 years) well-integrated blade implant in the left premolar-molar region with an extension for No. 20 crown connected rigidly to the natural crown No. 22 (Figure 8). A moderate degree of extrusion of the lower anterior teeth was evident. Teeth No. 23 through 27 had short clinical porcelain fused to metal (PFM) crowns and were stable. The bridge No. 28-29-30 was in a poor periodontal state and temporarily was not included in the treatment plan per patient's request. To better assess premaxillary bone resorption, a tomographic three-dimensional bone survey (CT scan) was ordered. It demonstrated an advanced volumetric maxillary bone atrophy of the anterior maxilla, extending from No. 3 area on the right to tooth No. 12 on the left (Figures 9 and 10).

Diagnosis

On the basis of the clinical and radiographic evaluation, the diagnosis of combination syndrome was made. An extended diagnosis also included a class III malocclusion, severe anterior maxillary bone atrophy between first premolars, failing tooth No. 2 (advanced periodontal condition), a functional mandibular blade implant, an extrusion of the lower front teeth, and a poor fit of a new maxillary RPD due to failure of tooth No. 2.

Treatment plan

During the initial surgical consultation, the overall oral condition and severe bone atrophy was discussed with the patient. The remaining tooth No. 2 was not salvageable and had to be removed. Teeth No. 12-13-14 connected in the bridge were stable. A surgical treatment with a large bone graft (hip graft) to the premaxillary region to correct severe atrophy which would require hospitalization was proposed but not accepted by the patient. She asked for an alternative treatment plan that could involve implants to improve retention of her new upper partial denture. After re-examining study models, tomographic x-rays, and a multi-disciplinary discussion (the surgeon, restorative practitioner, and technician), the treatment plan was formulated. It consisted of extraction of tooth No. 2 (chronic severe localized periodontitis) with an immediate placement of two implants and direct (lateral) sinus lift procedure in the right maxillary sinus region. A consideration for an immediate insertion of 2 implants in the right posterior maxilla was based on the CT scan evaluation that illustrated a radiographically available bone volume present for initial implant stability. When osseointegrated, these two implants



FIGURES 8–11. FIGURE 8. Panoramic radiograph depicting anterior maxillary bone loss, blade implant in the left posterior mandible, and severe periodontal condition of tooth No. 2. Combination syndrome classification: Class II, Mod. 2 (II-2). FIGURES 9 and 10. Tomographic images showing severe maxillary resorption to the basal bone between teeth No. 3 and No. 12. FIGURE 11. Post-operative periapical radiograph of two 4-mm Lifecore implants inserted in posterior maxillary bone in the area of extracted tooth No. 2.

on the right side would be interconnected by a mesobar with an attachment mechanism that would work in concert with an existing upper left bridge No. 12-13-14 for the retention of patient's existing upper partial denture. Patient agreed with the proposed procedure, signed the consent form, and had the surgery done under local anesthesia. The mounted diagnosed models and surgical stent were provided for the surgeon preoperatively. A relined upper partial denture was used postoperatively for the patient's comfort and function.

Operative phase

The procedure (surgical stage 1) was started with the administration of two capsules of lidocaine 2% with epinephrine 1:100 000 for the upper right quadrant. The buccal full-thickness flap from the right maxillary tuberosity to the premolar area with the anterior releasing incision was developed. The maxillary sinus was exposed by removing a small amount of anterior maxillary wall bone mesial to the tooth No. 2 with a No. 6 round diamond bur (Osteomed, Addison, Tx). The floor of the maxillary sinus and a Schneiderian membrane were visualized. The membrane was then carefully elevated with sinus curettes (Salvin Dental Specialties, Inc., Charlotte, NC) and tooth No. 2 was extracted atraumatically with a periotome and universal upper forceps. The volume of preserved alveolar bone, in agreement with the preoperative tomographic images, appeared sufficient for the placement of two standard diameter implants in the area No. 2 and 3. Two Lifecore implants (Lifecore Biomedical, Inc., Chaska, Minn) were inserted into the bone with help of the surgical stent: implant No. 2 was placed into the interradicular bone between the anterior and posterior buccal root sockets of extracted tooth No. 2, implant No. 3 was inserted 7 mm anteriorly and parallel to No. 2. Both Lifecore implants were external

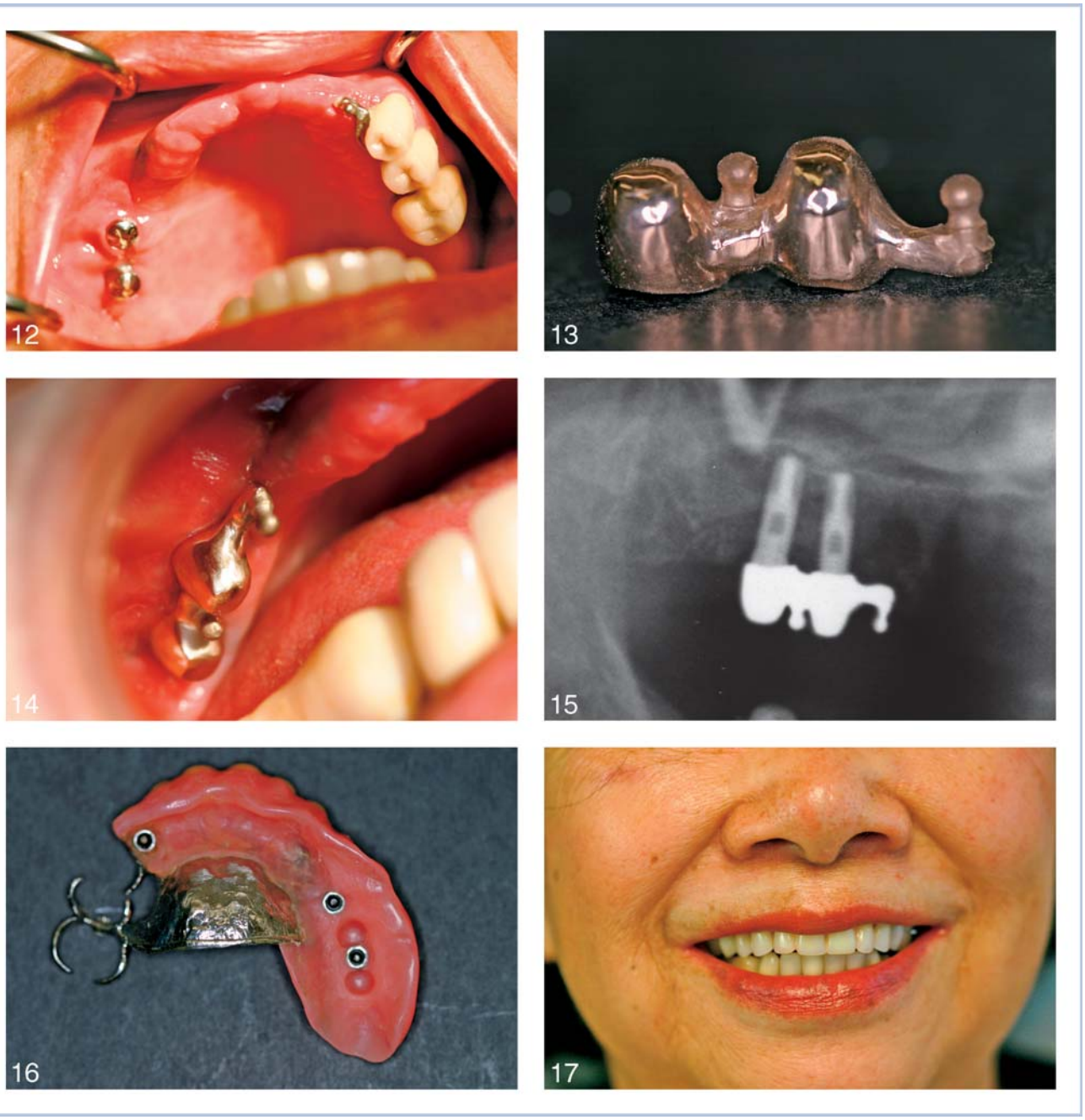


FIGURE 12–17. FIGURE 12. Clinical post-operative photo of the same patient after the stage 2. Two healing abutments can be seen in the upper right quadrant and 3-splinted PFM crowns (No. 12-13-14) with a mesial O-ring attachment in the upper left quadrant. FIGURE 13. A platinum-palladium-gold (type IV) alloy framework of the mesobar consisted of 2 abutment copings with 2 male protruding components of the O-ring system. FIGURE 14. The mesobar cemented on implant abutments with two O-ring male implant attachments for retention of the partial implant overdenture. FIGURE 15. Panoramic radiograph (close view) depicting 2 implants in the right posterior maxilla with the mesobar in place. Two abutment copings and 2 O-ring attachments can be seen: one in-between two copings and one on the mesial end of the mesobar. FIGURE 16. Maxillary partial implant-retained overdenture at the delivery stage with 3 female components of the O-ring system inside the denture and clasps for the existing bridge No. 12-13-14. FIGURE 17. Post-completion photograph of the patient in the case report wearing the maxillary implant overdenture and showing harmonious soft tissue relationship of the lower face.

hex (Restore), 4 mm in diameter, and 11.5 mm in length. About 2 mm of the apical portion of both implants were projecting into the sinus cavity above the sinus floor and below the elevated Schneiderian membrane. The 3 cm^3 of cancellous bone grafting material, consisting of autogenous bone that was harvested from the adjacent maxillary tuberosity, was placed in the created subantral pocket around the

implants. The buccal flap was then mobilized and closed primarily with 4–0 chromic gut (Henry Schein Inc., Melville, NY). A panoramic X ray after the procedure confirmed good placement of both implants. Patient took amoxicillin, 500 mg (2 g 1 hour before the surgery and 500 mg 3 times daily for 5 days postoperatively) for infection control, and ibuprofen 600 mg as needed for pain. A postoperative period was uneventful.

Surgical stage 2 was done 6 months after stage 1. Under local anesthesia, a small buccal flap was developed and both implants were exposed and found to be rigid and fully integrated into the bone. Two temporary healing abutments were placed and the flaps were closed around them (Figures 11 and 12). One month later the patient was referred for the restorative stage.

Restorative stage

Bar type attachments are often used to connect abutment teeth or implants and provide retention for removable dentures and overdentures. Retention is achieved by using riders/clips, retention sleeves, O-rings, etc. There are several bar type attachments that are available commercially, including the Dolder Bar System, the Hader Bar System, the Acherman Clip, and others. Any type of bar attachment can be referred to as a primary or meso bar. In this case report, a mesobar using O-rings was used to connect two endosteal implants and provide retention for a maxillary removable implant-retained overdenture.

After osseointegration, the healing collars were removed and prepable permanent abutments inserted. The abutments were prepared with high-speed diamonds and water coolant. A polyvinyl siloxane impression Aquasil (Dentsply, Lakewood, Colo), bite registration, and opposing impression were taken and sent to the laboratory. Two abutment copings were waxed in the lab and connected by a wax mesobar. One male O-ring attachment (ball shaped) was waxed on top of the mesobar between abutments and another mesial to the anterior abutment. The mesobar had an ovate pontic appearance proximal to the tissue. It was cast with type IV gold alloy and tried-in over the implant abutments (Figure 13). The passive fit of the mesobar was confirmed clinically and radiographically. Two female gold-plated retainer rings (metal housings) with rubber O-rings inside were placed onto the male protruded components. The acrylic portion of the existing maxillary RPD in the implant area was hollowed out to allow enough room to receive the framework and check the occlusion. The existing partial denture was placed back and had a passive fit without occlusal interferences. A cold cure acrylic was then added inside the hollowed area of the prosthesis. It was then placed back in the mouth to recheck the occlusion again, and the acrylic was allowed to set in the mouth. Once the acrylic was set, the prosthesis was removed together with the metal framework. The mesobar was then separated from the prosthesis and placed back on implant abutments, leaving two O-ring female housings still remaining in the partial denture. The partial denture was then cleaned and tried-in the mouth once more. All denture determinants, including a group function occlusion bilaterally, centric relation, midline, vertical dimensions, esthetics, and patient's comfort were found satisfactory. The partial implant overdenture was then removed and the mesobar was cemented to implant abutments with permanent cement (Panavia F 2.0, Kuraray Dental, Japan) (Figures 14 and 15). At the completion of the restorative stage, the modified maxillary implant overdenture had a bilateral retention provided on the right side by 2 new O-ring attachments and on the left side by an already existing O-ring attachment on the mesial end of the bridge No. 12-13-14 and clasps (Figure 16). An implant-retained partial overdenture helped to support patient's upper lip and provided harmonious lower facial proportions (Figure 17). Once the procedure was completed, the patient received instructions for function and hygiene. Patient's expectations for the improved retention of her upper partial denture were met and she was satisfied with the final result.

Classification of Combination Syndrome

Kelly was the first person to use the term "combination syndrome."[5] He believed that the key to many symptoms of the combination syndrome is the "early loss of bone from the anterior part of the maxillary jaw."[3] The other consistent features of this dental condition include enlargement of maxillary tuberosities and mandibular posterior bone resorption that can be present in many but not all CS cases. Based on a literature review and the author's experience with a variety of combination syndrome patients (complete and partial maxillary and mandibular edentulous cases), a clinically relevant classification of combination syndrome is proposed. Three classes and 10 modifications of CS are described below. An anterior maxillary resorption resulting from the force of anterior mandibular teeth is the key feature of this classification, and it is consistently present throughout all classes and all modifications. "Maxillary edentulous condition" defines the class, "mandibular" the modification within

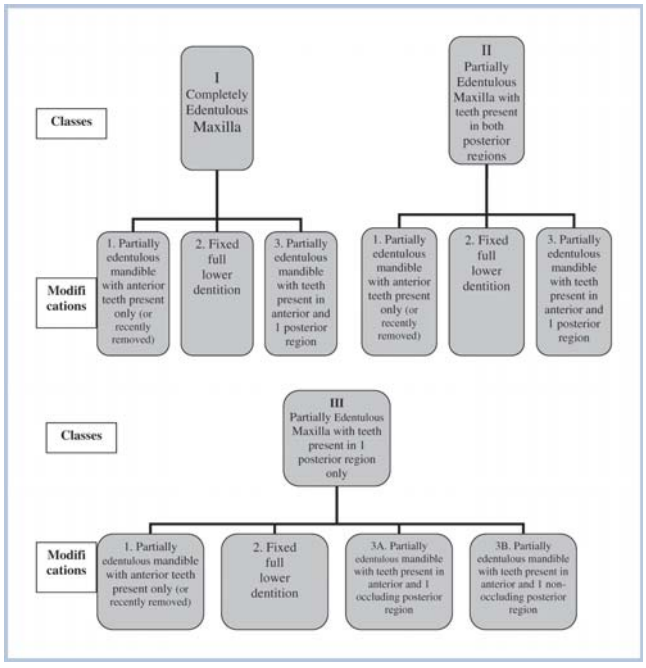


FIGURE 18. Classification of combination syndrome: 3 classes and 10 modifications (10 clinical presentations of the combination syndrome).

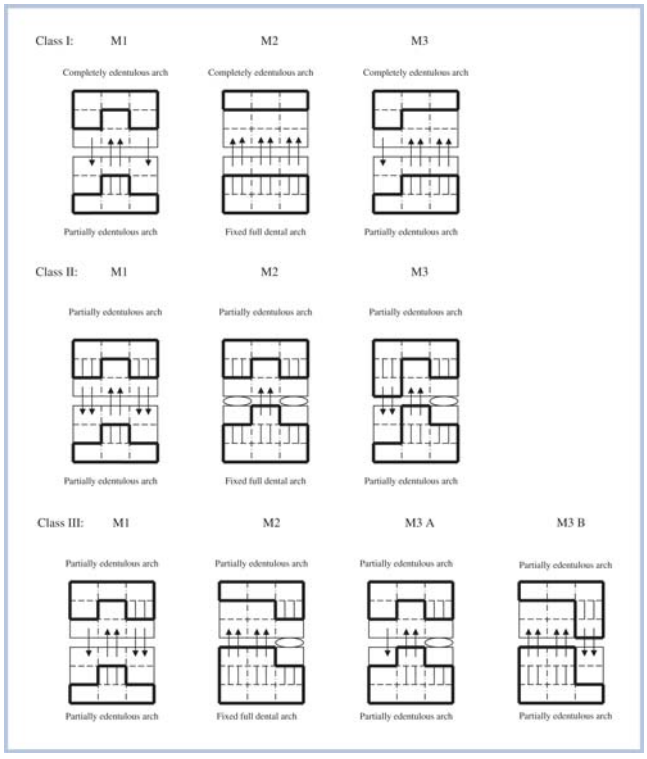


FIGURE 19. Classification of combination syndrome (CS): 3 classes and 10 modifications. M: CS modifications (M1, M2, M3, A and B); shapes in solid heavy lines represent bone-teeth complex that undergoes changes in the particular modification of CS (maxillary and mandibular jaw/teeth shapes match, like a jigsaw puzzle); arrows: the direction of alveolar remodeling (hypertrophy) and teeth movement (super-eruption) in certain jaw regions (single arrows—moderate degree: in cases of edentulous regions opposed each other, double arrows—severe degree: in cases when an edentulous region is opposed by teeth); 3 columns represent anterior and 2 posterior stomatognathic regions; basal row represents bone (alveolar ridge), middle row represents dentition, and top row represents bone and teeth remodeling changes (atrophy, hypertrophy, extrusion) in a particular modification of CS; vertical thin solid lines: natural teeth (fixed dentition) or an implant-supported bridge in a specific region of the jaws; oval represents no change status (no bone remodeling or teeth movement) in the region of preserved posterior occlusion.

the class. A treatment for each category of patients with CS is suggested (Figures 18 and 19, Table).

- Class I: Maxilla: completely edentulous alveolar ridge. Mandible: Modification 1 (M1): partially edentulous ridge with preserved anterior teeth only. Modification 2 (M2): stable "fixed" full dentition (natural teeth or implant-supported crowns/bridges). Modification 3 (M3): partially edentulous ridge with preserved teeth in anterior and one posterior region.
- Class II: Maxilla: partially edentulous alveolar ridge with teeth present in both posterior regions, edentulous and atrophic anterior region. Mandible: modifications are the same as in Class I (M1, M2, and M3).
- Class III: Maxilla: partially edentulous alveolar ridge with teeth present in one posterior region only, edentulous and atrophic anterior and one posterior region.Mandible: modifications are consistent with Class I and II (M1, M2, M3A, and M3B) (Figure 18).

This classification is based on what seems to be the dominant feature of most CS cases—an edentulous premaxilla with an advanced resorption of anterior maxillary bone and overgrowth of the anterior mandibular bone with extrusion (super-eruption) of lower front teeth.

According to this classification, the patient in the presented case report (Figures 6 through 10) had Class II, Mod. 2 (II-2): a partially edentulous maxilla with the posterior teeth present bilaterally opposed by the full fixed (crown and bridge) dentition. The typical (and the most commonly observed in the dental practice) case of CS exemplified at the beginning of this article and in Figures 1 through 3 would be Class I, Mod. 1 (I-1): a completely edentulous maxilla opposed by the partially edentulous mandible with preserved anterior teeth only. Similar cases can also be observed with a fully edentulous maxilla and mandible where the anterior mandibular teeth have been recently removed. The damage from these teeth that caused typical signs and symptoms of the CS still remains. That is why

TABLE

Classification of combination syndrome (CS)*

CS Class	CS Modification	Type of Maxillary Edentulism	Type of Mandibular Edentulism	Anterior Maxilla	Anterior Mandible
I	1	Completely edentulous arch	Partial edentulism with anterior teeth present only (or recently removed)	Severe atrophy	Severe hypertrophy; teeth extrusion
	2	Completely edentulous arch	Fixed dentition	Severe atrophy	Severe hypertrophy
	3	Completely edentulous arch	Partial edentulism with anterior and posterior teeth on one side	Severe atrophy	Severe hypertrophy
II	1	Partially edentulous arch with posterior teeth present on both sides	Partial edentulism with anterior teeth present only (or recently removed)	Severe atrophy	Severe hypertrophy
	2	Partially edentulous arch with posterior teeth present on both sides	Fixed dentition	Severe atrophy	Severe hypertrophy
	3	Partially edentulous arch with posterior teeth present on both sides	Partial edentulism with anterior and posterior teeth on one side	Severe atrophy	Severe hypertrophy
III	1	Partial edentulous arch with posterior teeth present on one side only	Partial edentulism with anterior teeth present only (or recently removed)	Severe atrophy	Severe hypertrophy
	2	Partial edentulous arch with posterior teeth present on one side only	Fixed dentition	Severe atrophy	Severe hypertrophy
	3A	Partial edentulous arch with posterior teeth present on one side only	Partial edentulism with anterior and posterior teeth on one occluding side	Severe atrophy	Severe hypertrophy
	3B	Partial edentulous arch with posterior teeth present on one side only	Partial edentulism with anterior and posterior teeth on one nonoccluding side	Severe atrophy	Severe hypertrophy

*Conventional and implant treatment for each modification is suggested. FUD indicates full upper denture; RPD, removable partial denture.

these cases belong to the same classification category of Class I, Mod. 1 (I-1). The partial edentulous case depicted in the Figures 4 and 5 would be Class II, Mod. 3 (II-3): a partially edentulous maxilla with the posterior teeth present bilaterally opposed by the partially edentulous mandible with teeth present in anterior and one posterior region. In general, an extraction of teeth that initiated the specific pattern of the CS does not change the class and modification within the class. The classification would remain the

TABLE

Extended.

CS Class	CS Modification	Posterior Maxilla	Posterior Mandible	Conventional Treatment: Maxilla/Mandible	Suggested Implant Treatment of Maxillary Arch (Based on Bone Availability)
I	1	Moderate hypertrophy	Moderate atrophy	FUD/bilateral distal extension RPD	Placement of 2 to 4 implants in the posterior maxilla on each side, alveoloplasty ± sinus lift; implant-retained or supported overdenture
	2	Severe atrophy	Severe hypertrophy	FUD	Implants are unlikely
	3	Severe atrophy on one side and moderate hypertrophy on the other	Severe hypertrophy on one side and moderate atrophy on the other	FUD/unilateral distal extension RPD	Placement of 2 to 4 implants in the posterior maxilla on hypertrophic side, alveoloplasty ± sinus lift; implant-retained overdenture
II	1	Severe hypertrophy	Severe atrophy	Anterior extension RPD/bilateral distal extension RPD	Teeth extraction with placement of 2 to 4 implants in the posterior maxilla on each side ± sinus lift; implant-retained or supported overdenture
	2	No significant changes	No significant changes	Anterior extension RPD	Teeth extraction with placement of 2 to 4 implants in the posterior maxilla on each side ± sinus lift; implant-retained or supported overdenture
	3	Severe hypertrophy on one side and no changes on the other	Severe atrophy on one side and no changes on the other	Anterior extension RPD/unilateral distal extension RPD	Teeth extraction with placement of 2 to 4 implants in the posterior maxilla on each side ± sinus lift; implant-retained or supported overdenture
III	1	Different degree of hypertrophy on both sides	Different degree of atrophy on both sides	Unilateral distal extension RPD/bilateral distal extension RPD	Placement of 2 to 4 implants in the posterior maxilla on 1 or 2 sides ± extraction/sinus lift; implant-retained or supported overdenture
	2	Severe atrophy on one side and no changes on the other	Severe hypertrophy on one side and no changes on the other	Unilateral distal extension RPD	Placement of 2 to 4 implants in the posterior maxilla on one side ± extraction/sinus lift; implant-retained overdenture
	3A	Moderate hypertrophy on one side and no changes on the other	Moderate atrophy on one side and no changes on the other	Unilateral distal extension RPD for both jaws	Placement of 2 to 4 implants in the posterior maxilla on 1 or 2 sides ± extraction/sinus lift; implant-retained or supported overdenture
	3B	Severe atrophy on one side and severe hypertrophy on the other	Opposite of posterior maxilla	Unilateral distal extension RPD for both jaws	Placement of 2 to 4 implants in the posterior maxilla on 1 or 2 sides ± extraction/sinus lift; implant-retained overdenture

same, as if these teeth that are responsible for the CS jaws and teeth abnormalities were present.

An important consideration of this CS classification is the fact that a slow remodeling of bone with tendencies towards atrophy or hypertrophy (overgrowth) depends on unfavorable pairing of healthy teeth (or implant-supported bridge) in one jaw opposed by an edentulous region in the other jaw. A persistent occlusal pressure of solid teeth on the edentulous opposing alveolar ridge over time will cause a bone atrophy of the edentulous region. A reverse effect of hypertrophy of the alveolar bone with

an extrusion of teeth opposed by an edentulous jaw segment is also evident and usually develops synchronously. A pairing of healthy maxillary and mandibular teeth in a stable occlusion in any dental region can usually show little or no bone changes or teeth extrusion due to opposing forces that tend to cancel each other and maintain an occlusal balance (Figure 19). The forces of occlusal pressure causing bone remodeling towards atrophy or hypertrophy can cause mild, moderate, or severe changes. This depends on many factors, including presence or absence of teeth, history of tooth loss (trauma or extraction), periodontal condition of present teeth, history of edentulism and prosthetic treatment (removable or fixed, denture quality), an implant treatment (if done)—immediate or delayed, density of bone in the region, presence of parafunctional habits (bruxism), muscular facial biotype (brachycephalic), jaw relationship, type of occlusion, dietary habits, and other factors.

Discussion

Treatment of patients with combination syndrome can be a challenge for a dental practitioner. A significant resorption of anterior maxillary alveolar ridge is often seen when mandibular molars and premolars are lost and the anterior mandibular teeth with a distal extension RPD oppose the edentulous maxilla. When the lower RPD is constantly adjusted and properly maintained as the bone loss progresses, the deteriorating effects of CS can be postponed and less severe. When patients do not return for follow-up care and/or RPD is not well designed, the continuous resorption of the posterior mandibular bone leads to a loss of posterior occlusion with opposing maxillary denture teeth[3]. Mastication then shifts to the anterior regions that are bio-dynamically not designed for a heavy occlusal load. An adverse chronic pressure is placed on the anterior portion of a maxillary denture and the resorption of the premaxillary alveolar bone follows resulting in the combination syndrome (anterior hyperfunction). This unfortunate and progressive chain of events that causes an overgrowth and hypertrophy of some parts of maxilla and mandible as well as resorption and atrophy of other areas of the jaws is the result of a pathologic bone remodeling and can be explained by Wolff's law. Wolff's law states that "bone, either normal or abnormal, will develop the structure most suited to resist those forces acting on it."[33] In other words, bone is deposited and resorbed in accordance with the stresses placed upon it. Recent experimental research has also indicated that bone resorption is a pressure-regulated phenomenon.[34] Although theoretically these bone changes could be reversed with return to the original bone condition if the source of pressure is removed (pressure-counter pressure), practically these changes are permanent and do not reverse on their own.

Although a traditional treatment with a complete maxillary denture and distal extension mandibular partial denture is still common, osseointegrated implant-supported or retained treatment has become more prevalent and has physiologic indications in CS cases.

A surgical and prosthetic rehabilitation of these patients in the office setting with dental implants in many cases may appreciably control and correct the deteriorating effects of CS. An establishment of an implant-supported posterior occlusion can help to redistribute the heavy masticatory load posteriorly and allow anterior bone regions of the jaws to "rest." This can confront anterior hyperfunction and control anterior maxillary resorption.

Prior to or at the implant surgical phase, the hypertrophy of posterior maxilla and overgrowth of maxillary tuberosities can be corrected with an alveoloplasty and maxillary endosseous implants can be placed in a better vertical relationship. If subantral augmentation (sinus lift) is needed, this can also be done with a direct (Tatum) or indirect (Summers) method.

In the case described in this article and many other similar CS cases, 2 splinted implants for each posterior region of maxilla can provide retention for an implant-assisted overdenture. If possible, placement of 3 to 4 implants into the posterior maxilla on each side can provide a good foundation for an implant-supported fixed or removable prosthesis without an additional soft or hard tissue support. This often creates enough rigidity in the system to resist a prolonged posterior occlusal load in the area of poor bone quality.

It seems that using a single implant in the posterior maxilla on one or both sides in these cases will have little retention benefit over a conventional full upper denture. Also, non-splinting of implants placed into poor quality bone of posterior maxilla may compromise the treatment outcome due to a possibility of uneven load distribution and eventually an implant(s) loss.

Conclusion

A progressive anterior maxillary bone loss can be seen in cases of complete maxillary denture opposed by the distal extension RPD. A variety of similar situations when a maxillary partial denture with missing front teeth is functioning against an anterior fixed dentition or an implant-supported prosthesis (root-form, sub-

periosteal, ramus frame, transmandibular implant designs) can also eventually lead to the CS condition.[29]

Based on pathogenesis of this syndrome, four possible treatment modalities can be conceptually applied to attenuate or correct a traumatic anterior hyperfunction and treat CS. They are: (1) a properly designed removable mandibular partial denture around stable, mildly super-erupted anterior teeth opposed by a complete maxillary denture with even distribution of occlusal stresses over hard/soft tissues and careful maintenance through the follow-up care with a goal to preserve posterior occlusion.[3,35] In some cases, mandibular anterior teeth may need to be treated with root canal and have their clinical crowns shortened to place opposing maxillary incisors in a proper position; (2) an extraction of anterior mandibular teeth with/without alveoloplasty and construction of functional complete upper and lower dentures with a stable posterior occlusion with punctilious follow-up care and maintenance protocol; (3) an implant treatment of existing dentition with or without extraction of teeth to re-establish solid posterior occlusion with an implant-assisted or supported maxillary or mandibular prostheses; (4) using advanced maxillary bone grafting techniques to rebuild the maxillary anterior alveolar ridge in concert with one of the previous three options. The first two treatment modalities are conventional pre-implant symptomatic restorative techniques. The last two seem to be a causative physiologic surgical-prosthetic rehabilitation of the stomatognathic system that can prevent continuous bone deterioration and related signs and symptoms in CS patients.

According to our classification, Class I combination syndrome patients with totally edentulous maxilla can be treated in many cases with an implant-retained or supported maxillary prostheses based on 2 to 4 splinted implants placed in posterior maxillary regions opposed by the mandibular bilateral distal extension RPD. This can help to redistribute the occlusal load to the posterior regions and correct the condition.

Class II and III patients with partially edentulous maxilla and salvageable posterior teeth may best be treated with a well-designed and maintained conventional RPD. An implant prosthesis can be an alternative treatment in these cases (Table). Patients with poor posterior maxillary teeth may need an extraction and immediate or delayed implant placement with or without sinus lift for implant-retained or implant-supported prostheses. Due to poor quality of the posterior maxillary bone (type 3 or 4), at least 2 implants of sufficient length should be attempted on each side. After osseointegration, they should be splinted to increase the resistance to occlusal forces. An implant-supported prosthesis may demonstrate a bone-preserving effect that is the opposite of a conventional denture treatment that promotes continuing ridge resorption.[36]

A preservation of the health of natural dentition and its masticatory function are important keys to prevent progression of the CS. It is essential for dental practitioners (restorative and surgical) to identify initial symptoms of CS and initiate early corrective measures. An immediate or early replacement of lost teeth with dental implants can be one of the most effective treatment options that can circumvent the development of this syndrome. A multi-disciplinary approach is paramount to accomplish a complex task of comprehensive dental treatment of CS patients.

A proposed classification of combination syndrome may help to identify causes and forces of bone remodeling and assist in predicting stages of development of this condition, guiding a clinician towards an appropriate treatment protocol. Implant stomatognathic rehabilitation seems to be the most promising approach for these patients.

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