# Ramus Hinges for Excessive Movements of the Condyles: A New Dimension in Mandibular Tripodal Subperiosteal Implants

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KEY WORDS

**Hinged**
**Flexion**
**Flexibility**
**Implant-borne**
**Gonial angle**
**"Tug of war syndrome"**

*Some subperiosteal mandibular implants of the earlier designs failed because of bone resorption beneath the posterior portions of the implant. Conversely, bone loss was observed rarely in the anterior region. The resorption was more profound posteriorly because there can be as much as 250 lb. of biting force per square inch and the bone is more porous than in the symphyseal region, which receives about 25 lb. per square inch. The independent movements of the condyles and the inferior border of the mandible at the gonial angles have dictated the success or failure of conventional mandibular subperiosteal implants in many of the earlier designs. Often, the rigidity of the implant framework prevents its posterior portion from moving in unison with the flexion and flexibility of the condyles upon the opening and closing of the mouth. Flexure usually is 2–4 mm in range and varies according to the quality of bone, age, sex, and musculature of the patient. Approximately 2% of these patients demonstrate movements of up to 4 mm. This has influenced an altered approach to posterior design—especially with tripodal mandibular subperiosteal implants. A brief history of the contributions of the earlier pioneers and their important contributions to the subperiosteal implant follows: G. Dahl inserted the first mandibular subperiosteal implant and was awarded his patent in 1941. Gershkoff and Goldberg, were the first to report clinical cases with mandibular subperiosteal implants in the United States. N. Berman reported on a direct bone impression of the mandible and transosseous wiring of the implant to the bone for stabilization. I. Lew introduced his own surgical bone impression technique for the mandibular subperiosteal implant and had published case histories on maxillary and mandibular implants. B. D. Weinberg reported an early unilateral subperiosteal implant consisting of a latticework portion that seated over the bone connected to the protruding post by four uprights. Leonard I. Linkow reported on the posterior unilateral mandibular subperiosteal implant. He followed up with a 5-year report, an 8-year follow-up report, and a 12-year report. R. L. Bodine reported his experiences with mandibular subperiosteal implants. A. N. Cranin and P. Schnitman introduced the Brookdale bar for an improved support of an overdenture*

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*for the mandibular subperiosteal implants. L. I. Linkow made some significant changes in the mandibular subperiosteal implant. D. D'Alise reported on the O-ring design for retention of implant dentures. R. A. James reported on the support system and perigingival mechanism surrounding oral implants and changed the subperiosteal based on peri-implant tissue behavior. L. I. Linkow reported on an entirely new mandibular tripodal design concept as well as a distinct change in the surgical protocol for obtaining the bone impressions without exposing those parts of the body of the mandible from the mental nerves to the ascending rami.*

## INTRODUCTION

Millions of people in the United States suffer because of severely atrophied mandibles. Some have been told that iliac crest bone grafts are of benefit. Such procedures are time consuming, may cause dysesthesia, and, at times, discourage the use of root form implants because of the unpredictable behavior of the grafts. Some of these patients present with pretreatment paresthesia or anesthesia as well as pain from the pressure of their conventional dentures.

The treatment of these severely atrophied edentulous mandibles has always presented difficulties for dentists.[1–16] Restoring these patients with conventionally designed subperiosteal implants also presented problems (Figs 1–3). The standard incision was usually made from the retromolar pads, continuing anteriorly along the lingual sides of the ridge (to avoid the inferior alveolar nerve and mental neurovascular bundles), and then to the crest of the ridge in the symphyseal area mesial to the mental foramina. The simple reflection of the mucoperiosteal tissues often caused injury. Impression making also took its toll.[5,17–19] CAD-CAM procedures to eliminate the impression procedure were practiced by some surgeons.[20] Many of these problems were solved with the introduction of the tripodal designs.

The mandible is the unique, suspended deformable, and gravity-sensitive bone of the head. It is capable of undergoing a complex physiologic corporal deformation as well as a ramus deformation. The latter is known as ''mandibular flexion,'' which is defined as ''The closing of the condylo-symphyso-condylar arc (or angle) when the jaws are opened widely.'' The immediate consequence of this flexion is a rotational sliding-gliding movement of the two condyles inside the glenoid fossae until they come to a maximum contact with the inner wall of the fossae through the compressed interposing meniscus. The movement is reversed when the jaws are closed. The mandibular flexion, which may be measured by cinematic magnetic resonance imaging, is about 1–5 mm and can move as much as 4 mm at the condylar heads, 250–1000 μm at the gonial angle, and 100–400 μm at first bicuspid level where the corporal and ramus movements combine (Fig 4).[21,22]

Smith *et al*[23] demonstrated independently that the anterior surface of the rami and external oblique ridges are extremely dense relative to the author's prior conclusions for using those areas for posterior support. The extreme density of bone existing in the symphyseal as well as in both rami areas is due to the strong muscle attachments that exist in these regions, as can be demonstrated by doing cross-sections through the center of the symphysis and through the retromolar pads on each side of the mandible.

The anterior load-bearing area as related to stress adaptations at or near the midline of the symphysis as taken from cross section is strengthened by mentalis muscle, genioglossis and geniohyoid muscles, and digastric muscle.[24]

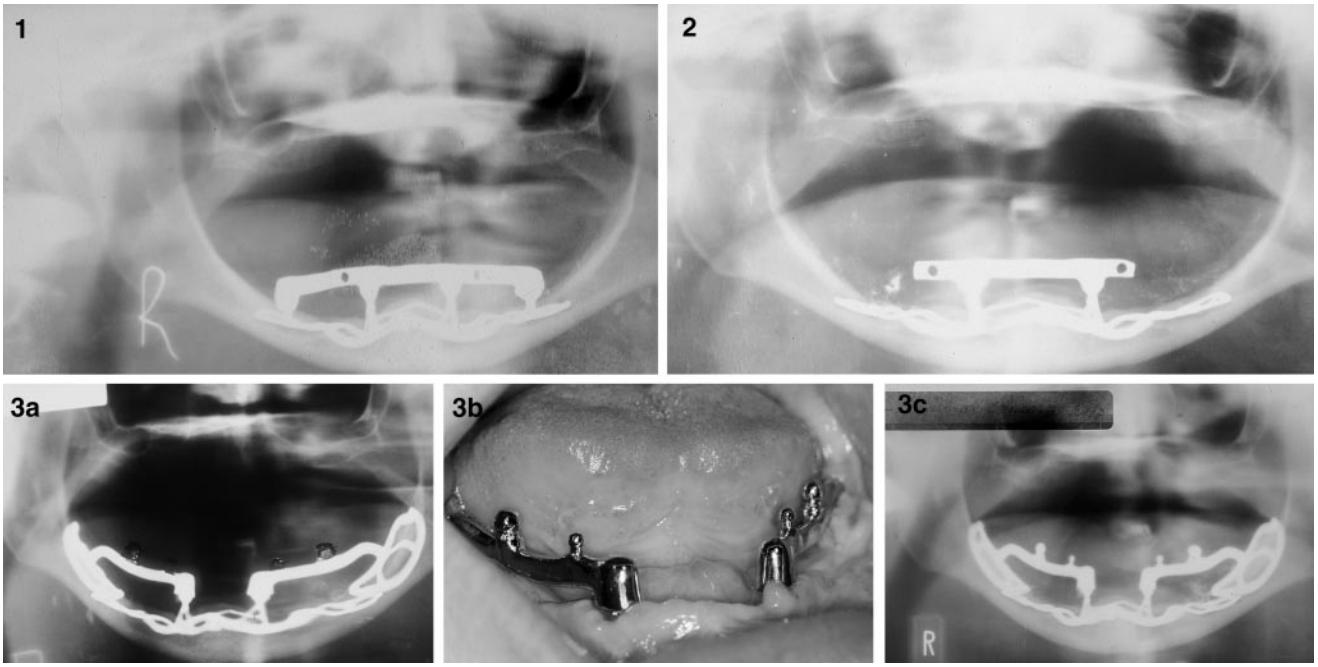
The postloading area as related to stress adaptations taken from various cross sections of the retromolar triangle are densified by the tendon of the temporalis muscle, mylohyoid muscle, and masseter muscle.[25]

The tripodal subperiosteal implant configuration has been found to be an improvement over earlier designs that fell short of the rami.[26–28] Between 1 and 2% of tripodal cases have problems of the soft tissues formed posteriorly and laterally that cover the buccal struts of the ramus portion. These cases seem to show more flexion at the condylar heads when the mouth is opened widely.[29–31]

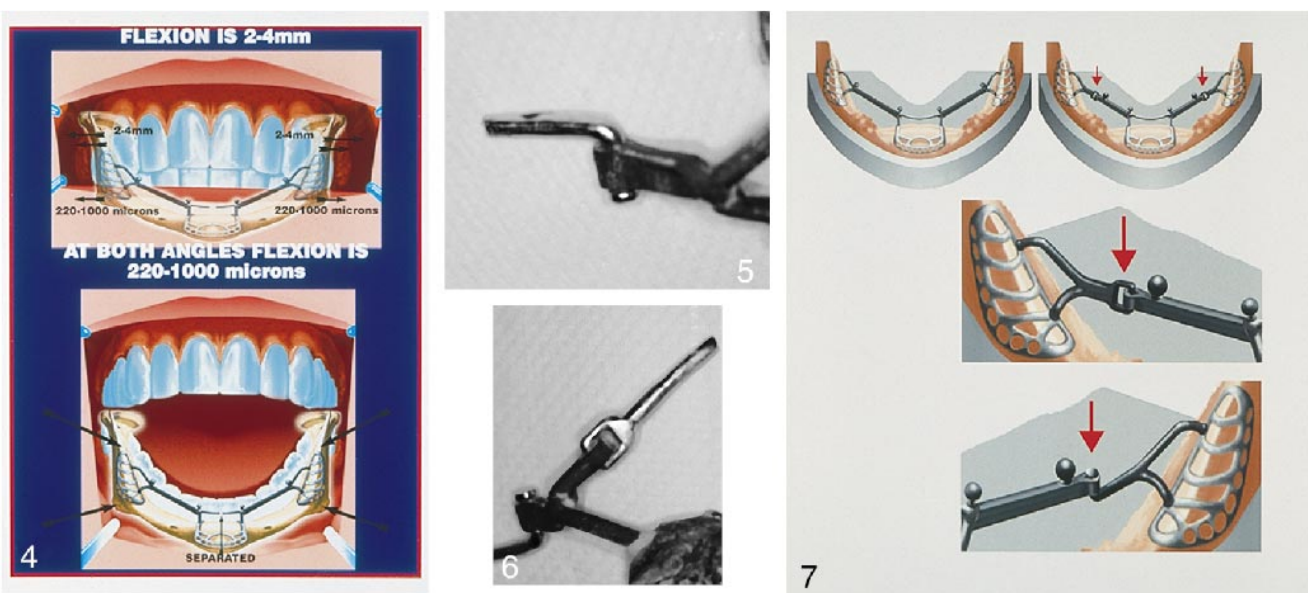
In essence, reciprocating forces may exist between the tissues and the buccal aspect of the rami with the struts sandwiched between. The tissues are under considerable strain, the severity of which depends on such factors as the muscular strength of the patient and the degree of flexibility of the rami (as influenced by their density). Other factors are age, sex, stature, and pernicious oral habits.

If the implant is designed to extend beneath the undercut areas found in the inferior half of the rami, discomfort may be caused during function. Formerly, a practice was to cut through the anterior portion of the mesobar to give slightly more independent movement of each posterior half of the implant so that it could flex with the movement of the proximal segment. However, it did not solve the problem in its entirety.

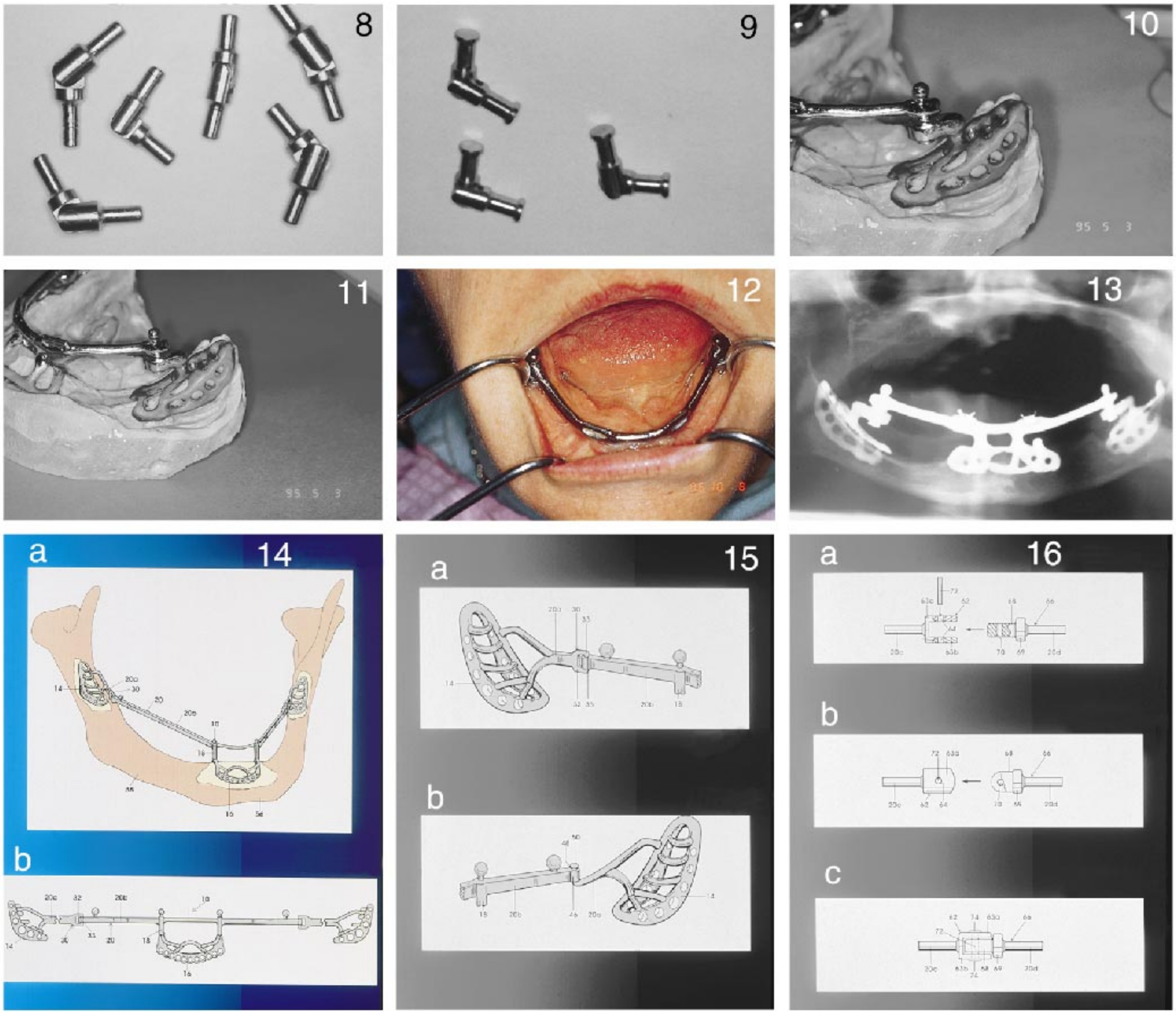
In cases where bar sectioning is not effective, various hinges have been developed[31] (Figs 5, 6), which, when placed along the posterior aspect of the mesobar between the ramus portions and the most posterior male O-ring configuration, present a more predictable solution (Fig 7).[32] These hinges permit inward and outward flexing of



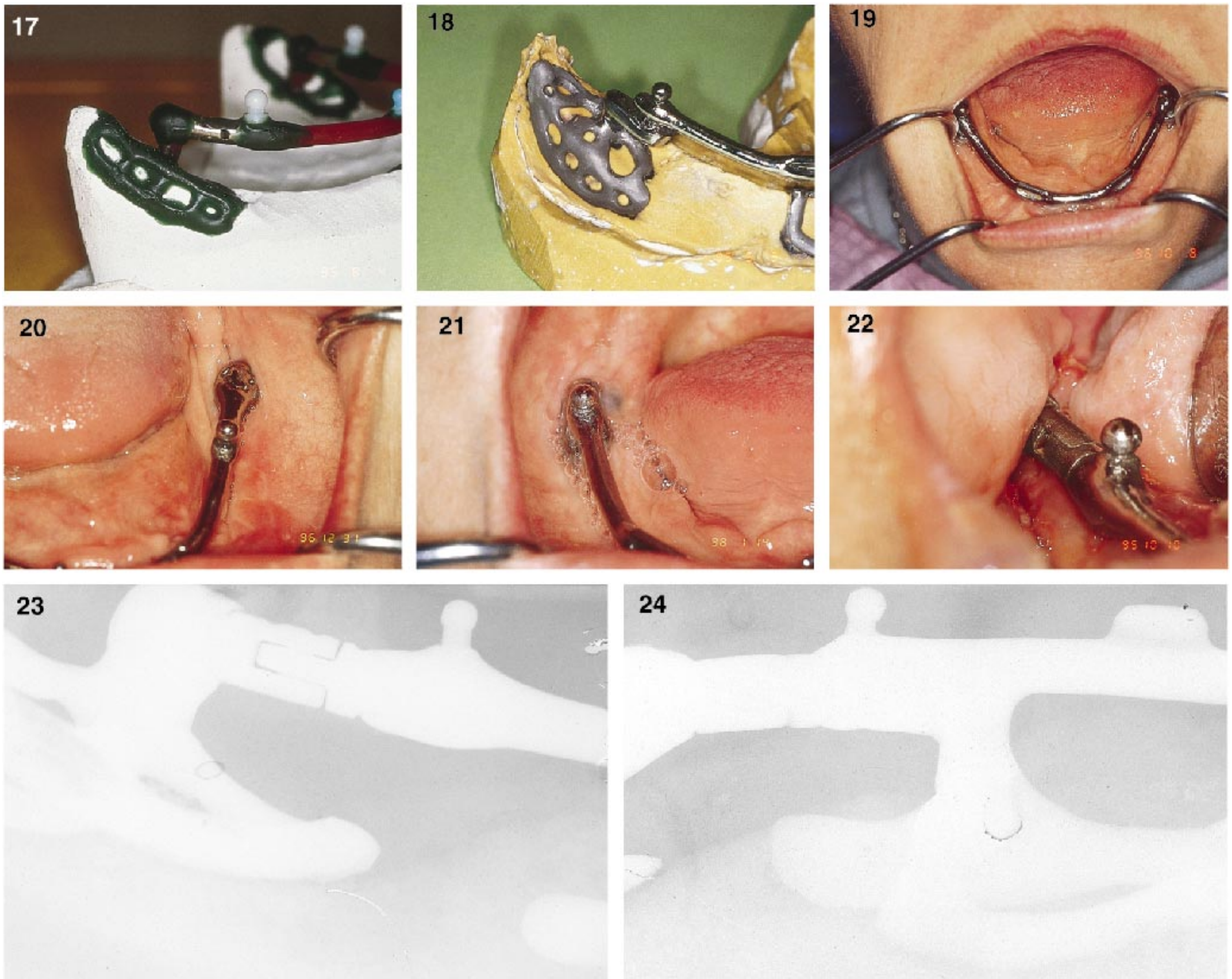

FIGURES 1–3. FIGURE 1. A panoramic x-ray showing an earlier designed implant that had settled posteriorly against the superior wall of both mandibular canals causing a ''tingling'' sensation along the patient's lips. FIGURE 2. The two posterior posts were cut off from their substructure and the distal portions of each side of the mesobar were also removed, immediately reducing pressure to the neurovascular bundles. Prior to preparing for the ramus surgery, the entire mesobar was removed, leaving the existing implant with its two posts in the anterior region. Two unilateral subperiosteal implants were designed to fit over each ramus. Extending anteriorly from each implant was a horizontal bar with an anterior attached coping that slid over and around each anterior implant post and was cemented on to it. In this manner, all occlusal forces were distributed between the anterior portion of the implant and the ''joined'' implants that rested over the rami, thus eliminating any pressure over both canals. The tingling disappeared after 3 months. FIGURE 3. (a) The immediate postoperative panoramic x-ray. (b) Eight years later, the original connecting bar was changed to a gold mesobar with male O-ring extensions for improved retention for a new overdenture. (c) A panoramic x-ray taken more than 18 years postoperatively with the new mesobar with male O-ring extensions.




FIGURES 4–7. FIGURE 4. The condyles move from 2 to 4 mm inward when a patient opens his/her mouth and flexes outward the same amount when the mouth is closed. FIGURES 5, 6. The very first prototypes roughly cast in vitallium illustrating the first two types of ramus hinges. FIGURE 7. The two different types of hinges that should always be located distal to the last male O-ring extension and mesial to the ramus portion of the implant.




FIGURES 8–16. FIGURE 8. ''Ready made'' hinges. FIGURE 9. In order to attain an exact mechanical look between the implant and hinge, the implant was further designed with the knobs at each end. FIGURES 10, 11. The hinges are readily seen in their positions along the implant casting. FIGURE 12. A clinical view of a bilateral hinged tripodal mandibular subperiosteal implant. FIGURE 13. A postoperative panoramic radiograph of the implant. FIGURE 14 (a, b) A rendering of a tripodal mandibular subperiosteal implant with the location of the hinges. Each hinge (30) is preferably formed so that the eyelet (35) cannot move vertically relative to the hinge pin (33). This maintains vertical alignment of the implant arms (20) and prevents vertical shifting of one arm portion relative to the other. Of course, the hinge pin (33) and eyelet (35) can be on the respective ends of the other arm portions from what is shown. FIGURE 15. (a, b) A detailed drawing of both types of hinges. Here, the posterior end of each symphyseal strut (20b) (remote from the ramus subperiosteal portion) has a hole (46). The anterior end (remote from ramus portion 14) of each ramus arm strut (20a) has a pivot post (48) that is pivotable within the hole (46). The post (48) has a head (50) to retain it within the hole and to prevent vertical movement of one arm portion relative to the other. Here also, the pivot post (48) and pivot hole (46) can be changed relative to the arm portions (20a, 20b) from what is shown. FIGURE 16. (a, b, c) Three detailed renderings of the mechanics and design of this later type hinge. Here, one hinge part (62) has bifurcated arms (63a, 63b) that project from an extension (20c). Arms (63) are flattened and have rounded front ends. A hole (64) extends through both arms (63a, 63b). The other hinge portion (66) has a flattened tongue (68) that projects from a collar (69) at the end of an extension (20d). This tongue (68) has a curved front end and a hole 70. The tongue (68) fits into the space below the two arms (63a, 63b) of the hinge piece (62). A hinge pin (72) extends through the holes (64) of the arm (63) and the tongue (68). The ends of the pin (72) are flattened to form heads (74) at each end to prevent the hinge parts (62, 68) from separating. The two hinge portions (62, 68) rotate to each other around the hinge pin (72). The curved front ends of the arms (63) and the tongue (68) permit free rotation. The fit of the tongue (68) within the arms (63) is relatively tight so that the hinge parts do not shift vertically with respect to each other.




FIGURES 17–24. FIGURE 17. The titanium hinge is included in the wax-up of the implant. FIGURE 18. The titanium cast implant and hinge. FIGURE 19. Clinical view of another tripodal implant with the prefabricated hinges. FIGURES 20, 21. The clinical view of both hinges. FIGURE 22. A close-up clinical view of the hinge. FIGURES 23, 24. Two periapical films of these ''ready made'' hinges in two separate places.

the rami portions in unison with condylar movements, which eliminates the strain that may be causing pain. It is imperative that these hinges are designed to flex no more than 4 or 5 mm. The first two cases failed almost immediately because the hinges were designed to have unlimited movement (Figs 8, 9).

Figures 10 and 11 show a titanium casting of a tripodal mandibular subperiosteal implant with ramus hinges on each side distal to the most posterior O-ring extension. A clinical view shows the implant, hinges, and surrounding tissues (Fig 12). A postoperative panoramic x-ray clearly illustrates the hinge structure (Fig 13). These hinges discourage the possible detachment of the implant from the buccal surface of the rami with eventual formation of granulation tissue between these buccal struts and the underlying bone, which could lead to their failure. The hinges are hand tooled or manufactured separately from pure titanium, titanium alloy, or vitallium.

Extending mesially and distally from the hinge are two rounded bars approximately 5–7 mm in length and 1.5 mm in diameter. At each end is a flat, rounded disc of a slightly wider diameter than the rounded bar to allow for a mechanical locking of the hinge to the bar. These ''ready made'' hinges are placed in their proper positions and are included in the wax-up of the tripodal subperiosteal implant by waxing several millimeters around their two horizontal rounded extension bars prior to casting (Figs 17, 18). Clinically, the tissue accepts the titanium castings with the attached hinges (Figs 19–22). Periapical films clearly show the prefabricated hinges posterior to the last O-ring extension (Figs 23, 24).

## CONCLUSION

The tripodal mandibular subperiosteal implant was designed to function successfully in those situations where, because of dehiscencies or near dehiscencies of the inferior alveolar nerves, mental neurovascular bundles, or unattached gingival tissues in the posterior body of the mandible as well as poor tissue tonicity or integrity, posterior post supports were inadvisable.[26,33,41] In these atrophic situations, a horizontal bar was made to extend from both anterior posts to join with the lingual peripheral strut situated on the lingual side of the anterior surface of each ramus portion of the implant, thus totally bypassing the body of the mandible on each side of the arch.

The tripodal subperiosteal implant configuration has been found to be an improvement over the earlier designs that fell short of the rami.[35–40] Approximately 2% of the cases having problems of soft tissue involvement seem to occur along the tissues posteriorly and buccally that cover the buccal struts of the ramus portion of the implant and the bone beneath.

Finally, with the introduction of the hinges, the rami portions of the mandibular tripodal subperiosteal implant are able to move in unison with the condyles, which seem to avoid ''the tug of war'' effect that has occurred in the past with rigid castings and excessive flexibility of the condyles.

## ACKNOWLEDGMENTS

Leonard Linkow wishes to give credit to two of his loyal technicians, Manuel and Jessica Guerrero, for mastering the difficult task of casting the pure titanium subperiosteal implants with the complicated ramus hinge technique.

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