Natural tooth intrusion and reversal in implant-assisted prosthesis: Evidence of and a hypothesis for the occurrence

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Based on clinical observation, a hypothesis of the mechanism of intrusion of natural teeth in an implant-assisted prosthesis is suggested. Engineering principles are presented that establish an energy absorption model as it relates to the implant-assisted prosthesis. In addition, in the course of patient treatment it has been discovered that the intrusion of natural teeth can be reversed. Patient histories that demonstrate intrusion reversal are reviewed. The possible mechanisms for the intrusion/reversal phenomenon are presented and preventative recommendations are given. (J Prosthet Dent 1993;70:513-20.)

There is a recognition among dentists that natural teeth combined with implants may be subject to intrusion.[1] Rieder and Parel[2] recently reported an international survey about natural tooth abutment intrusion with implant-connected fixed partial dentures. Their results indicated that when intrusion occurred, it was generally considered a nonreversible phenomenon and there was controversy regarding the cause. The four categories of suspected causative factors mentioned by the survey respondents were: disuse atrophy, debris impaction, impaired rebound memory, and mechanical binding. All of these theories leave unanswered questions. However, as Reider and Parel[2] stated, "There is no question that intrusion of natural tooth abutments does occur in all areas of the mouth without being specifically related to retainer design."

There are numerous references in the implant literature in regard to the importance of dampening occlusal forces. The Brånemark System (Nobelpharma USA, Chicago, Ill.) advocated that the occlusal surfaces of prostheses be reconstructed with acrylic resin.[3] The IMZ System (Interpore International, Irvine, Calif.) has an internal shock absorber made of a medical-grade polyoxymethylene (POM) incorporated into the implant design.[4] Numerous articles have addressed the potential significance of a periodontal ligament substitute for the rigid implant system.[3-7] It has also been noted that research related to dental implants has empirically addressed the subject of occlusal load transfer; however, it is void of studies that quantify, through in vitro human or animal models, the energy absorption of restorative materials.[6, 8] Energy absorption is defined as energy dissipated by inelastic deformation processes.

Of even greater clinical concern is the immediate question of how to treat an intruded tooth. This article describes this phenomena and offers an explanation for its occurrence.

Patient 1

A 66-year-old woman was referred by her physician for dental evaluation. She had a medical history of hypertension and mild hypothyroidism, and her daily medications included nifedipine (Procardia, Pfizer Laboratories Div., New York, N. Y.), levothyroxine sodium (Synthroid, Boots-Flint, Inc., Lincolnshire, Ill.) and conjugated estrogens (Premarin, Wyeth-Ayerst Laboratories, Philadelphia, Pa.). On examination, it was observed that she had moderate to severe periodontitis. The maxillary right third molar, second premolar, first premolar, cuspid, the maxillary left first premolar, first molar, and third molar, the mandibular left third molar, first molar, second premolar, and the mandibular right third molar were absent. Numerous inadequate restorations were present. The patient had a long history of bruxing and clenching. Comprehensive treatment included a combined periodontal-restorative treatment plan that included implant placements.

Periodontal therapy was completed within 6 months. Sterioss implants (Denar Corp., Anaheim, Calif.) were placed by the periodontist in the areas of the maxillary right second premolar, first premolar, and cuspid. Normal surgical protocol was used and included the use of a surgical guide. At the time of surgery, it was noted that the first premolar implant had a poor prognosis because of the poor bone quality. This implant was removed at the second stage of surgery 7 months later.

Prosthodontic rehabilitation was without incident. The right maxilla was restored with a ceramometal tooth and implant-supported prosthesis that extended from the right second molar to the left lateral incisor (Fig. 1). Individual

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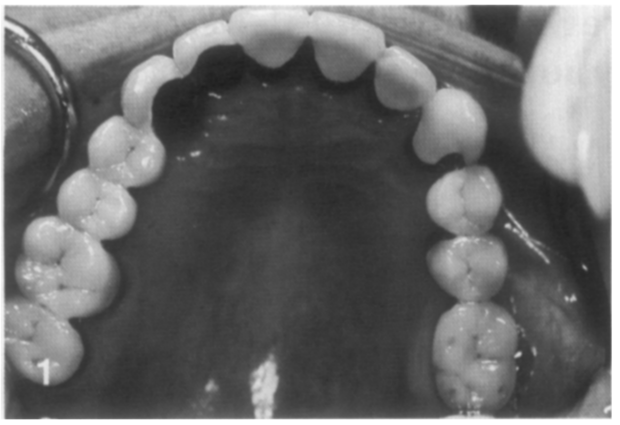


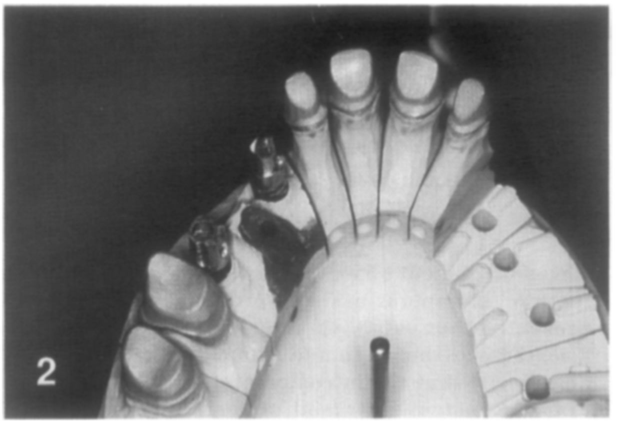


Fig. 1. Restorations in place.

Fig. 2. Custom-milled copings for natural and implant abutments placed to support 10-unit ceramometal prosthesis.

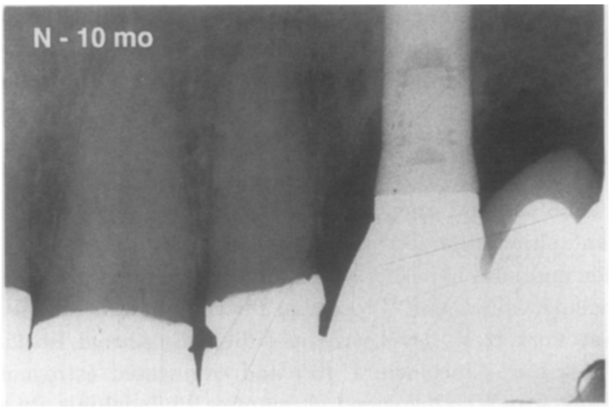


Fig. 3. Ten months after insertion, 1.5 mm intruded lateral incisor. Small marginal openings between copings and superstructure for adjacent central incisor are seen (N – 10 months).

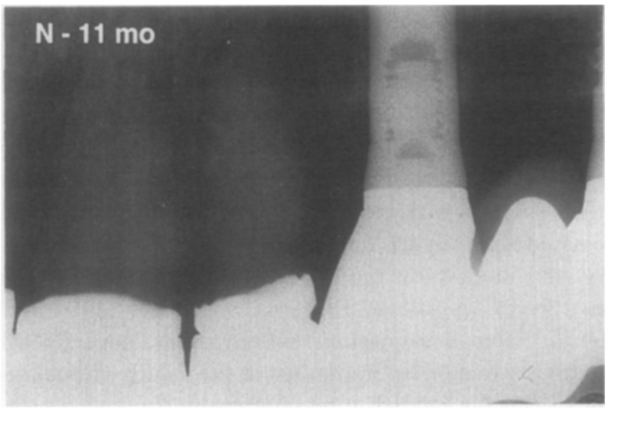


Fig. 5. Radiograph at 1 month indicates diminution of space between lateral incisor coping and superstructure (N – 11 months).

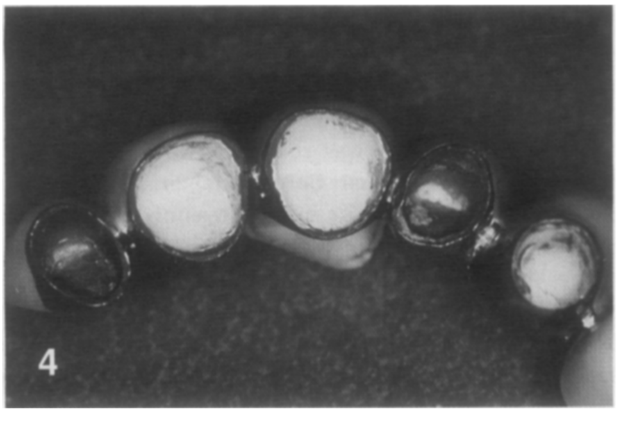


Fig. 4. Cement is absent in both lateral incisor superstructure crowns. Beginning deterioration of cement is also evident in central incisor areas.

gold-milled copings were used on the natural and implant abutments beneath this prosthesis (Fig. 2). Temporary cement, (Temp-Bond, Kerr Manufacturing, Co., Romulus, Mich.), was used to secure the prosthesis. The remaining natural teeth were restored with ceramometal crowns and a fixed partial denture.

Ten months after cementation, it was noted that the maxillary right lateral incisor was intruding. On careful examination and with radiographic confirmation (Fig. 3), it was determined that this tooth had intruded approximately 1.5 mm, and small marginal openings between the copings and the prostheses were also noted on the right central incisor and the left lateral incisor.

Removal of the superstructure revealed an absence of cement in both the right lateral incisor and the left lateral incisor superstructure crown areas (Fig. 4). In addition, the cement in the central incisor superstructure crowns was

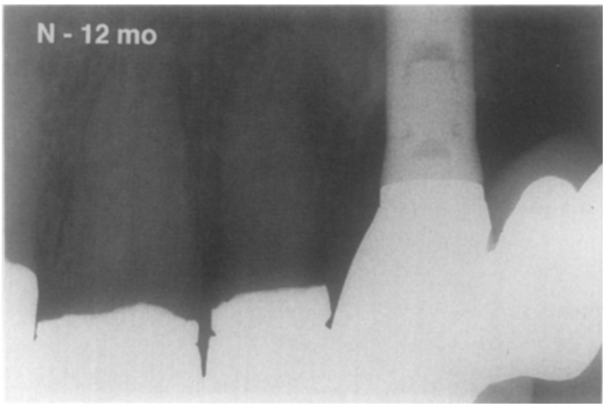


Fig. 6. Radiograph at 7 weeks does not show additional improvement (N – 12 months).

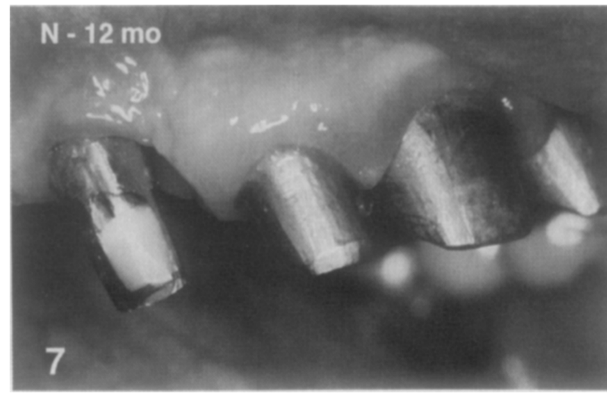


Fig. 7. Rigid coping reduced 1.5 mm to 2 mm incisally and superstructure replaced.

beginning to deteriorate. There was no sign of food impaction.

Because of the time, effort, and expense the dental reconstruction represented to this patient, conservative management was suggested. One of the authors has previously noted that periodontally involved teeth that change position will reseat in a superstructure if it is temporarily worn without cement. A protocol of treatment based on this premise was established.

The superstructure was cleaned and reseated with petroleum jelly. The patient returned to be examined weekly. Partial intrusion reversal was noted at the 1-week examination. Four weeks later, the right central incisor and left lateral incisor were completely reseated in the superstructure. The right lateral incisor was within 0.5 mm of the marginal closure (Fig. 5). The patient's teeth were reevaluated 3 weeks later, but only minor tooth movement was noted (Fig. 6).

Some dampening effect for the right cuspid implant area was then attempted because it received both vertical and lateral forces. The implant coping was shortened approximately 1.5 mm (Fig. 7). The superstructure was then recemented with temporary cement giving approximately 1.5 mm of cement for energy absorption for the right cuspid implant. The superstructure crown for the right lateral incisor contained only petroleum jelly. Four weeks later, the right lateral incisor was completely seated in the superstructure (Fig. 8). The superstructure, including the right lateral incisor, was recemented with temporary cement and has remained stable for 1 year with no indication of further intrusion.

Patient 2

A 68-year-old woman was referred for an evaluation by her periodontist (Fig. 9). The medical history revealed an allergy to penicillin. Synthroid levothyroxine was taken daily and there was no hormone replacement therapy. The

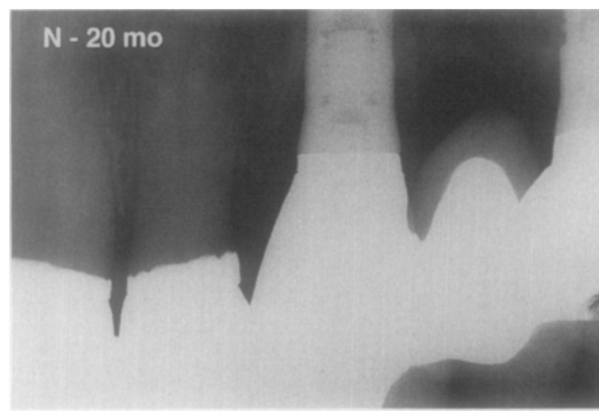


Fig. 8. Lateral incisor coping repositioned in superstructure 6 months after reduction in height of implant coping (N – 20 months).

maxillary right third molar, first molar, third molar, the mandibular left third molar, first molar, second premolar, and first premolar and the mandibular right third molar were absent. The occlusal vertical dimension was diminished. A significant bruxing-habit pattern was noted. There was a history of solder joint failure on a long-span fixed partial denture that extended between the mandibular left second molar and cuspid.

A combined periodontal and restorative treatment plan that included implants was developed. Sterioss implants in the mandibular left first molar and first premolar areas were placed by the treating periodontist. Standard surgical techniques were followed and included the use of a surgical guide. The teeth were restored with ceramometal restorations with porcelain occlusal surfaces. A provisional prosthesis was placed in the left mandibular quadrant of the patient's mouth before the definitive restoration. The final restoration included individual milled copings under a ceramometal superstructure with porcelain occlusal sur-

Fig. 9. Pretreatment occlusal status.
Fig. 10. Restored mandibular occlusal surfaces.

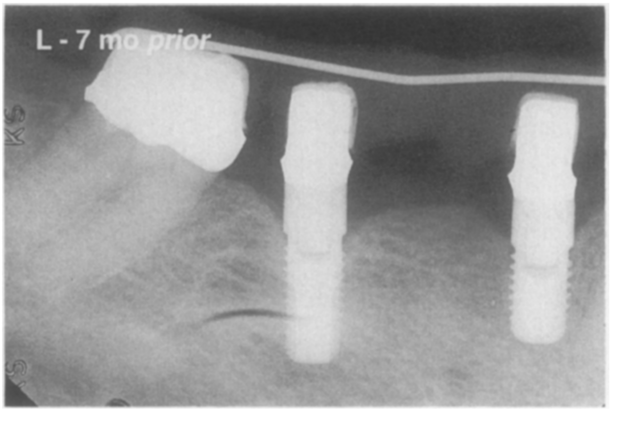


Fig. 11. Radiograph shows relationship of gingival margins of molar coping and coping on distal implant fixture. Relationship between mesial gingival margin of coping for molar and alveolar crest is notable.

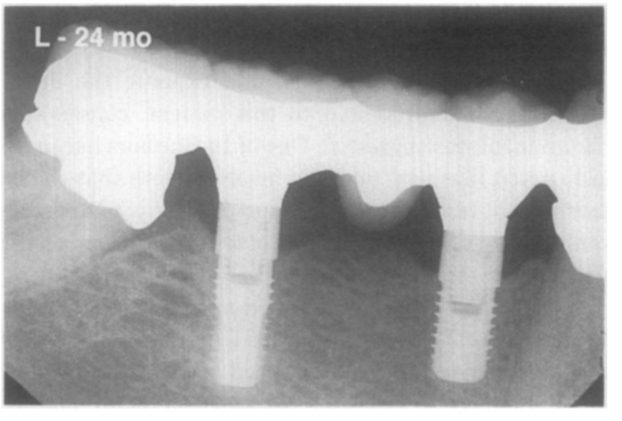


Fig. 13. At 24 months (L = 24 months) molar intrusion of approximately 4 mm can be seen. Cuspid intrusion remains constant at approximately 0.5 mm.

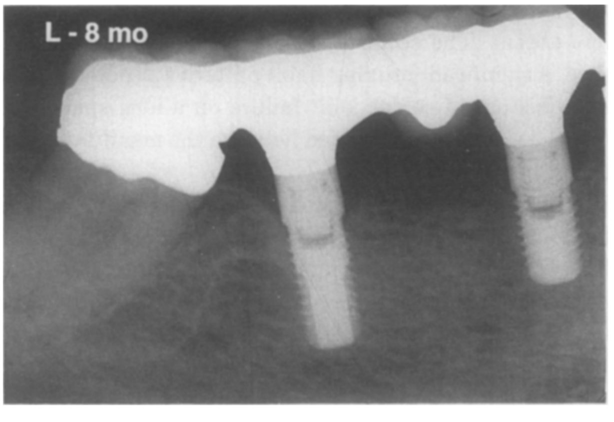


Fig. 12. Radiograph 8 months after placement of definitive prosthesis reveals molar abutment intrusion of approximately 1 mm and some cuspid abutment intrusion (L – 8 months).

faces that extended from the mandibular left second molar to cuspid (Fig. 10).

Fig. 11 shows the relative relationship between the mesial coping margin on the second molar and the distal coping margin on the posterior implant abutment during the provisionalization stage, 7 months before cementation of the final prosthesis. Also notable was the distance between the mesial coping margin in the second molar and the alveolar crest. With many intermittent steps, the final crowns, custom-milled copings, and ceramometal superstructure were placed. A maxillary protective occlusal splint was made in an effort to minimize the effects of bruxism. Daytime clenching pattern remained unchanged and unprotected.

Eight months after the cementation of the superstructure, routine radiographs revealed signs of intrusion between the coping and the superstructure on the mesial side of the second molar and the distal side of the cuspid (Fig.

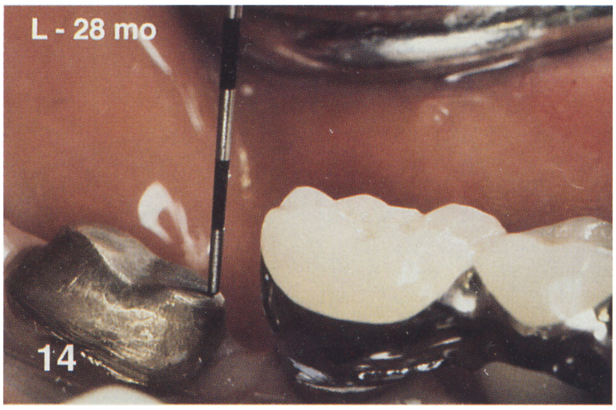


Fig. 14. Shortened superstructure with intruded unrestored gold coping (L − 28 months).
Fig. 15. Seven months after separations of molar crown. Distal occlusal surface appears at near normal height. Mesial occlusal surface erupted to within 2 mm of original position (L − 32 months).

12). Twenty-four months after cementation of the superstructure, the mandibular left cuspid had remained consistent at approximately 0.5 mm of intrusion, but the mandibular left second molar had intruded approximately 4 mm (Fig. 13). On removal of the superstructure, food impaction was evident in the coping for the second molar. No food was found in the coping for the cuspid.

Several treatment options discussed at this time included the possibility of additional telescopic copings placed on the second molar and the cuspid to alleviate the marginal discrepancy caused by the intrusion of the natural teeth. Because the mechanism of intrusion was not yet understood, this option was not selected for fear of causing additional intrusion.

In addition to the intrusion of the second molar and the cuspid, the internal threads of both implant abutments had deformed and the copings had loosened. The implant copings were removed, custom wrenches were fabricated, and the implant copings were reseated. Each implant coping when reseated was one quarter turn to the right beyond the initial position. Hyperrotation of one-piece abutments have been described.[9] A provisional fixed partial denture was placed.

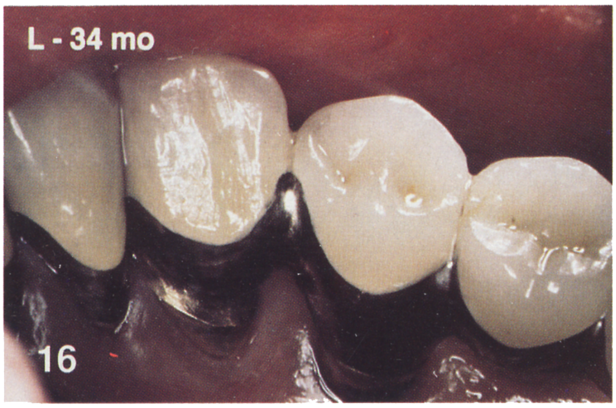
In the laboratory the superstructure was refitted to the new position of the implant copings. At a subsequent appointment the patient agreed to allow the superstructure to be placed uncemented. She removed the superstructure after each meal to clean any accumulated debris. Safety instructions were given to prevent fracture of the porcelain or injury of the margins. The patient understood the experimental nature of the procedure.

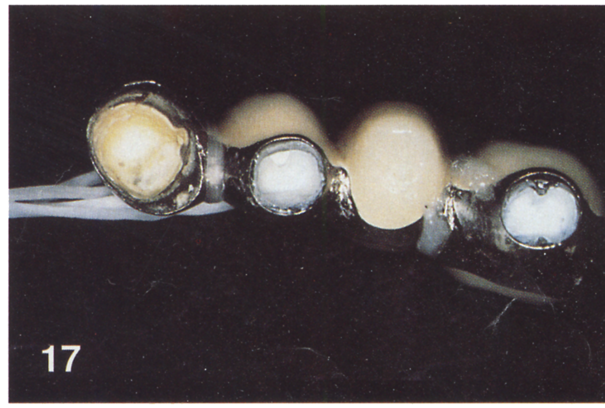
Three weeks later, the second molar had erupted 1 mm. The cuspid was showing approximately 1 mm of marginal discrepancy due to intrusion. One month later, the implant coping abutment for the first bicuspid had loosened and was reseated with an endodontic sealer paste. Because of the patient inconvenience of maintaining the removable superstructure, the crown for the second molar was cut from the superstructure. The modified superstructure was cemented with temporary cement. The second molar was maintained with only the gold milled coping (Fig. 14).

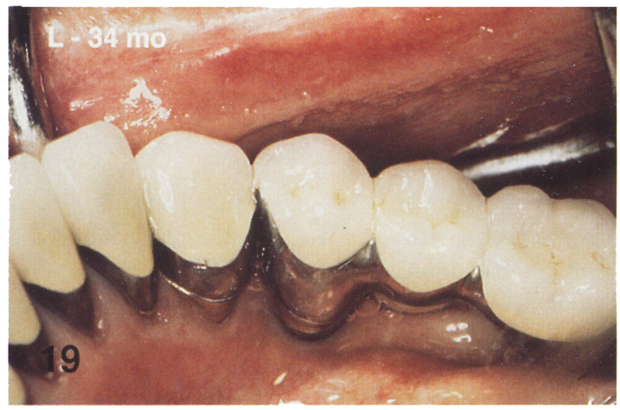
The patient was dentally evaluated every 2 weeks. Five months later, reeruption of the second molar seemed stabilized. The mesial occlusion portion of the crown was approximately 2 mm submerged and the distal occlusal portion was at normal height (Fig. 15). A new single ceramometal crown was made to correct the occlusal plane. On the day of cementation of the new crown, it was noted that the cuspid had continued to intrude to a 2 mm marginal discrepancy (1 mm additional intrusion beyond the original situation) (Fig. 16). Because of suspicion that excessive mechanical energy was now directed at the only natural tooth left under the superstructure, the superstructure was removed and examined.

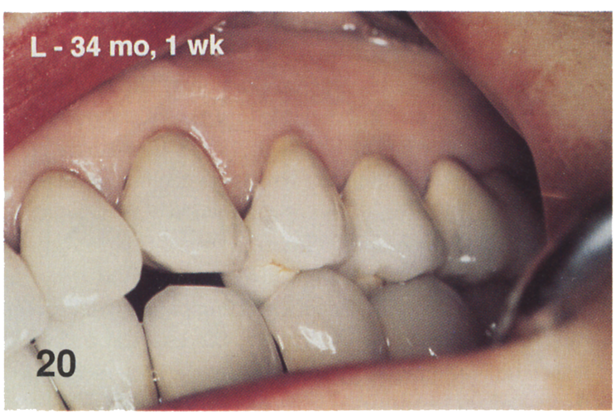
The temporary cement was deteriorating in the crown of the cuspid, but no food impaction was evident (Fig. 17). The superstructure was cut between the first bicuspid implant and the cuspid and repolished. The cuspid crown was cemented with temporary cement as an independent crown 2 mm out of occlusal contact (Figs. 18 and 19).

Five days later occlusal movement was detected (Fig. 20). The patient was observed at 1-month intervals. Photographs were taken to document the tooth position at each visit. The cuspid is presently close to occlusal contact and is still under observation (Fig. 21). If the cuspid does not completely reerupt to its preintrusion position, a new crown will be fabricated to reestablish cuspid guidance. The maxillary right cuspid has been maintained in its original position because of nightly use of a maxillary protective occlusal splint. The mandibular left second molar









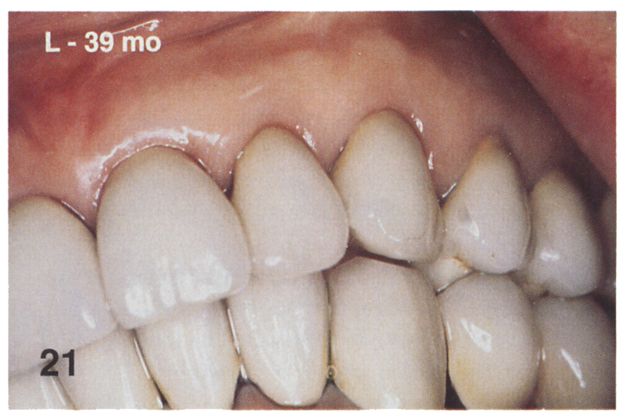


Fig. 16. Cuspid has intruded approximately 2 mm.

Fig. 17. Deteriorating cement is evident in cuspid crown.

Fig. 18. Two mm occlusal discrepancy exists on cementation of single crown, eliminating any potential for cuspid disclusion (L – 34 months).

Fig. 19. Lingual view shows sealed margin (L – 34 months).

Fig. 20. Cuspid relationship 5 days after crown was cut from superstructure. (L – 34 months, 1 week).

Fig. 21. Cuspid relationship 5 months after crown was cut from superstructure (L – 39 months).

remains stabilized in its new position as an independent tooth.

DISCUSSION

The sudden application of force on a solid body generally results in a stress wave that propagates through the body from the impacted surface. All solids that undergo impact loading deform both elastically and inelastically.[16] Elastic deformation is energy-conservative by nature, in that stress-strain hysteresis is not produced when a specimen is loaded and subsequently unloaded (Fig. 22). Inelastic deformation, however, is nonconservative by na-

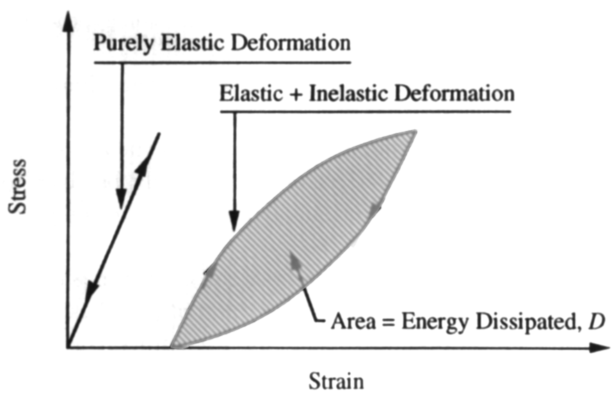


Fig. 22. Schematic depictions of purely elastic deformation and elastic + inelastic deformation on plot of stress versus strain.

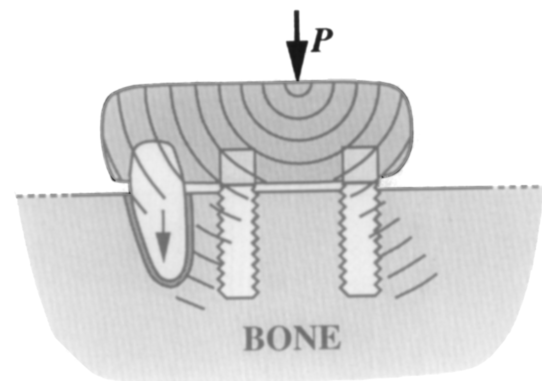


Fig. 24. Schematic drawing depicts stress waves passing through two implants and their surrounding bone. Natural tooth is primary recipient of stress resulting in intrusion of tooth.

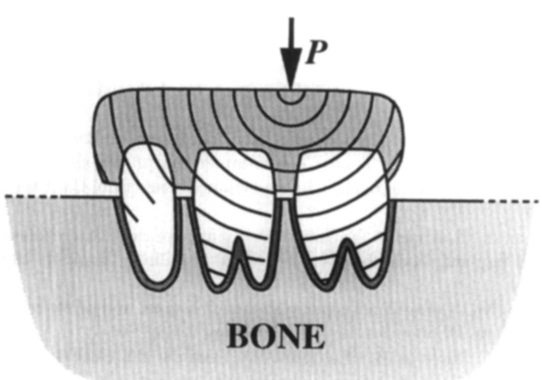


Fig. 23. Schematic drawing depicts stress waves propagating from point of percussion *(P)* on superstructure into three natural teeth. Energy is absorbed by tooth-periodontal ligament complex.

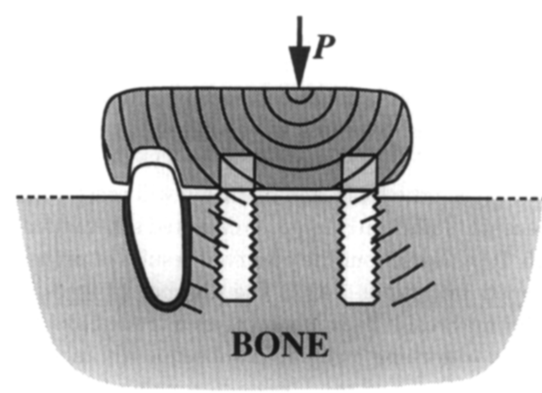


Fig. 25. Schematic drawing depicts new equilibrium that resulted between implants and natural tooth once it had intruded sufficient distance from superstructure.

ture and gives rise to energy dissipation when a specimen is loaded as depicted schematically by the area of the hysteresis loop in Fig. 22. The relative extent to which a material deforms inelastically and dampens elastic energy may be characterized as its loss coefficient, η, given by:

$$\eta = \frac{D}{2\pi U}$$

where D is the total energy dissipated per unit volume and U is the elastic energy per unit volume generated at the maximum applied stress.[11] The energy of an elastic wave attenuates after it has traveled a relatively short distance in materials with a high-loss coefficient. By contrast, elastic waves in materials with a low-loss coefficient travel much further before attenuation occurs.

A schematic depiction of the propagation of stress waves from a superstructure into natural teeth is illustrated in Fig. 23. In this case, the stress waves from the point of percussion P are attenuated in the periodontal ligaments of the supporting teeth. Another schematic that depicts a superstructure supported by two implants and a natural tooth is illustrated in Fig. 24. As shown in this figure, stress waves may reach the tooth through the implants and bone as well as from the superstructure directly. On reaching teeth attached to the superstructure, the energy of these stress waves depends on their initial energy and on the damping properties of the gold alloy superstructure ($\eta \approx 10^{-2}$),[11] the titanium implant ($\eta \approx 10^{-4}$),[11] and bone ($\eta \approx 10^{-2}$).[12] By contrast, stress waves generated at the surface of natural teeth must pass through the ligament ($\eta \approx 1$)[13] before they reach neighboring teeth as illustrated in Fig. 23. Because the loss coefficients of both the implant and the superstructure materials are relatively low, the tooth periodontum also receives reflected stress waves from all parts of the superstructure and bone with little dissipation. It should be noted that stress waves may be transmitted through a thin film of saliva or pieces of compacted food. Therefore, stress waves may continue to pass into the

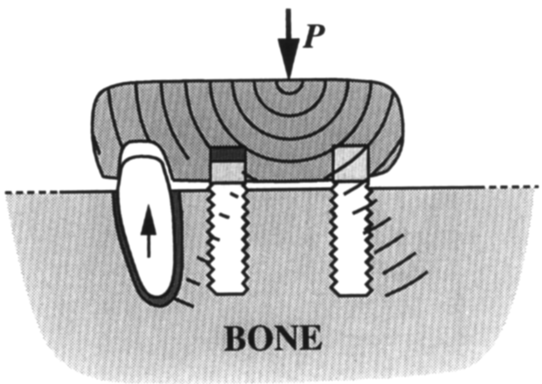


Fig. 26. Schematic drawing depicts implants, bone, and natural tooth after energy-absorbing element placed in implant nearest tooth. Attenuation of stress waves by energy-absorbing element allows tooth extrusion.

tooth periodontum without attenuating as long as the gap between a tooth and the superstructure is small or contains compacted food. It follows that this stimulus results in the observed intrusion because osteoclasts that surround the root are activated by stress wave energy.[6]

Stress waves from the superstructure will attenuate before they reach the tooth and intrusion will cease when the gap becomes sufficiently large, as depicted schematically in Fig. 25. It appears from the observed results of procedures performed in patient 1 that the absence of stress wave stimulus may result in extrusion of an intruded tooth when an energy-absorbing element is subsequently included in the neighboring implant. This phenomena is illustrated schematically in Fig. 26. In this situation the tooth receives little stress wave stimulus from either the superstructure directly or from the implant and bone. Therefore, the observations of this study suggest that an optimum range of mechanical stimuli is required to maintain a physiologic bone remodeling equilibrium. Excessive stimuli may lead to a disequilibrium in bone remodeling and intrusion whereas little or no stimulus may reverse this process and result in extrusion.

SUMMARY AND CONCLUSIONS

The results of the patient studies indicate that it may be important to consider an energy absorption mechanism for implants that closely matches that for natural teeth. It appears that it may be necessary in some situations to match energy damping on implants and natural teeth to maintain a physiologic bone remodeling equilibrium. Therefore, given current knowledge and available technology, the following is recommended:

1. When possible, natural teeth and implants should be independent of each other.
2. When natural teeth and implants are joined in an implant-assisted prosthesis, consideration might be given to including a mechanism for energy absorption in the prosthesis design.
3. Future studies should address the importance of energy absorption for the implant-supported prosthesis surrounded by natural teeth and for the implant-assisted prosthesis.
4. Future research should be directed toward determining the magnitude of energy absorption of an implant that is necessary to maintain a physiologic bone remodeling equilibrium.

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