Overload Management of Osseointegrated Fixtures to Achieve Optimum Bone Remodeling Through Multistage Prosthodontic Loading

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The overload management of osseointegrated fixtures to achieve optimum bone remodeling through multistage prosthodontic loading is a concept that initially evolved out of necessity, rather than pretreatment planning. With increased experience in tissue-integrated prosthesis treatment, some of the overload conditions affecting a bone-anchored prosthesis can be avoided.

Understanding the nature of the attachment between an implant and the host bone is fundamental to the long-range treatment planning process. There are four mechanisms for the interfacial attachment between implants and bone. These include:

1. Highly differentiated fibrous tissue
2. Low differentiated fibrous tissue
3. Use of artificial fixatives (such as bone cements)
4. Direct anchorage of the implant to vital bone—referred to as osseointegration

Brånemark and colleagues have stated that the critical point regarding osseointegration is that living bone and marrow must be made to heal as a highly differentiated tissue and not allowed to develop into low differentiated scar tissue.[1] Implants surrounded by low differentiated scar tissue have been unsuccessful in the past and often have led to a soft tissue inflammatory response and osteitis.

Prosthetic management of patients undergoing implant-supported prosthesis reconstruction begins with the treatment planning process. Direct management of these patients is critical immediately following fixture placement. It is during this healing period that the hematoma adjacent to the implant screw threads is transformed into new bone through a callous formation. The physiology of healing adjacent to the implant depends on revascularization of the bone followed by demineralization of injured bone and subsequent replacement with remineralized tissue. One highly critical aspect during this phase of the healing process is that no functional loading be applied to the implants.

Using resilient denture base materials provides a cushioned interface between the traditional denture prosthesis and the healing hard and soft tissues.

When cover screws are dehisced following fixture placement, the denture base must be relieved to avoid direct contact, which could transmit loading forces to the fixture. The removable prosthesis should be continually relined and relieved to maintain a soft cushion in the area where contact with the implant might occur under occlusal loading. If prolonged contact with the cover screw occurs at the time of fixture placement, fixtures placed in low-quality bone may be indirectly loaded via the resilient liners. This condition may produce micromovements between the implant and the healing bone, destroying the potential for osseointegration.

Normal loading

Functional loading of the fixtures should only occur following an initial osseous healing period. Traditionally, the recommended healing period has been 5 to 6 months in the maxilla and 3 to 4 months in the mandible, with bone of suitable quality and quantity. When the quality and quantity of bone is diminished, the initial healing period should be extended.

Excessive loading

For patients known to have parafunctional habits, special prosthetic treatment planning must be undertaken. Before discussing direct implant loading, prosthetic management of these patients following stage 1 surgery should be modified. Strong emphasis should be placed on the complete abstinence from denture use for 3 to 4 weeks immediately following fixture placement. If this is not practical, extra care must be taken in preparing the transitional denture for soft lining over the fixture sites. Patients must be instructed that the denture be removed and left out of the mouth as much as possible and most definitely during sleep, since this is frequently the time when parafunctional loading forces are generated. More frequent change of the soft liners is highly recommended to continuously provide the softest denture surface contact with the healing tissues.

Total initial healing time should also be extended from 3 months to 4 or 5 months in the normal mandible. With good quality and quantity of bone in the maxilla, the initial healing should be extended to 6 or 7 months before stage 2 surgery. If inferior bone quality is noted in either arch, the initial healing period may be extended up to 1 year.

In considering the gradual prosthetic loading concept of osseointegrated implants following stage 1 surgery, five levels of functional loading are suggested. The loading conditions are varied by the prosthesis format and materials used. These loading levels include:

1. Minimal load: The removable tissue-integrated prosthesis with a very soft resilient liner.
2. Light load: A removable tissue-integrated prosthesis with clip-bar retention.[2]
3. Moderate load: An all-acrylic resin fixed conversion prosthesis,[3,4] or rigid metal clip-retained overdenture.
4. Standard load: A fixed tissue-integrated prosthesis constructed of gold framework with acrylic resin veneer.[1]
5. High impact load: A fixed tissue-integrated prosthesis constructed of porcelain-fused-to-gold.

The standard design rules for prosthesis fabrication may require modification for patients exhibiting parafunctional loading. Rather than extending a cantilever two times the abutment width in the molar region, and four times abutment width in the incisal region,[5] one should consider shortening or even eliminating cantilevered extensions, especially in the posterior where loading forces can be magnified.

Through experience, time-frame guidelines have been established to provide optimal opportunity for bone remodeling. These time sequences are as follows:

1. Minimal load: Functional loading with overdentures using very soft tissue conditioner, or soft liner should proceed for 0 to 6 months.
2. Light load: During the next 6 to 12 months, a splinted gold clip-bar may be incorporated to gain additional retention.
3. Moderate load: After a full year of overdenture use with a clip-bar, a fixed conversion prosthesis or rigid clip-bar overdenture may be fabricated and used for 3 to 4 months if the quality of bone has permitted a positive remodeling response.
4. Standard load: Following moderate loading, the traditional gold and acrylic resin tissue-integrated prosthesis should be used for 2 years to produce positive bone modeling. The fabrication of the traditional Brånemark bone-anchored prosthesis, a fixed acrylic resin and gold tissue-integrated prosthesis may then be utilized. It is important to note that this prosthesis should have minimal or no cantilevers. If the patient experiences

Fig 1a Four-month use of the conversion prosthesis.

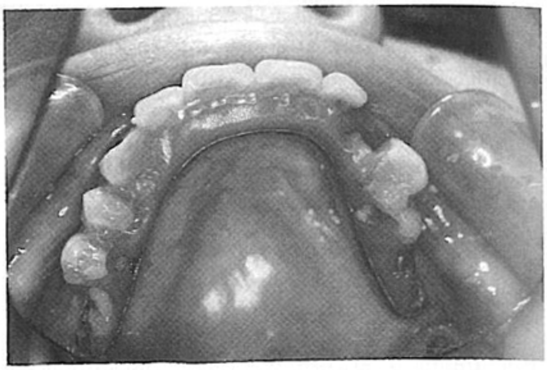

Fig 1b One year postprosthesis. Parafunction produced incisal attrition, fractured teeth, and lost vertical dimension of occlusion.

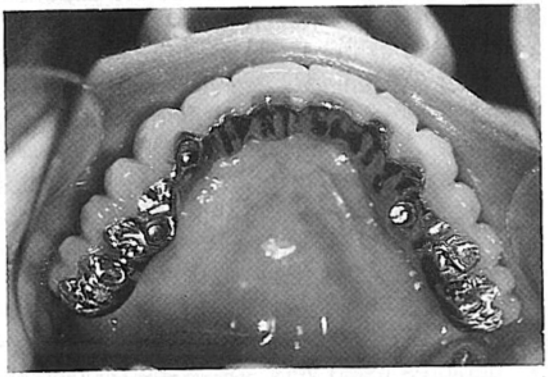

Fig 1c Gold occlusal and lingual surfaces designed to resist rapid wear produced by bruxism.

severe attrition of the prosthetic materials or is confronted by continuous maintenance problems such as fractured teeth or cracks in the veneering material, use of a more durable porcelain-fused-to-gold tissue-integrated prosthesis should be considered for the future.

5. High impact load: If functional loading remains successful during the previous period, the patient may then proceed with the next level of treatment. Use of a porcelain-fused-to-gold tissue-integrated prosthesis produces high-impact loads on the osseointegrated fixtures.

Clinical applications of the gradual loading concept

Rapid attrition

The first patient presented with oral debilitation, which required prosthetic rehabilitation. Although four long fixtures osseointegrated in relatively dense maxillary bone, it was evident during the 4-month use of the conversion prosthesis that the patient produced intense occlusal loading (Fig 1a).

The traditional Brånemark prosthesis consisting of a cast gold frame veneered with high-impact acrylic resin was placed following a 4-month fixture loading period with the conversion prosthesis.

Parafunctional forces in the form of bruxism produced severe incisal attrition as well as fractured denture teeth 1 year following the placement of this prosthesis (Fig 1b). In addition, severe occlusal wear patterns and deep facets were produced as a result of the bruxing condition. Maintenance and repairs for this prosthesis continued for a 2-year period.

To reduce the continuous maintenance and repair visits, a new tissue-integrated prosthesis was fabricated with a larger cast gold framework designed to deflect occlusal forces and protect incisal edges (Fig 1c) from the rapid attrition experienced with the traditional Brånemark restoration.

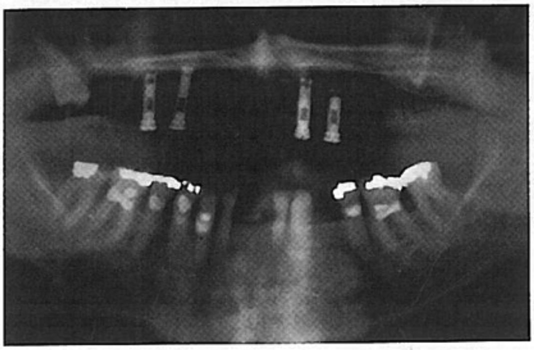

Fig 2a Increase in fixture support ratio illustrated by four additional fixture sites.

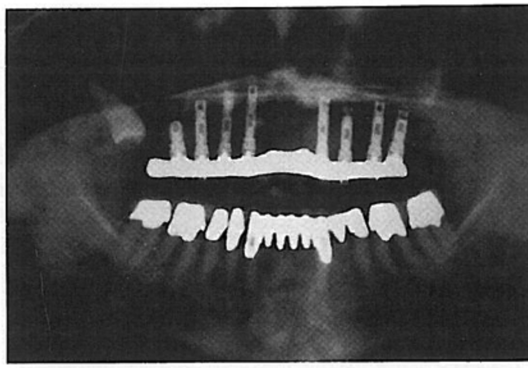

Fig 2b Radiograph of traditional Brånemark acrylic resin/gold tissue-integrated prosthesis.

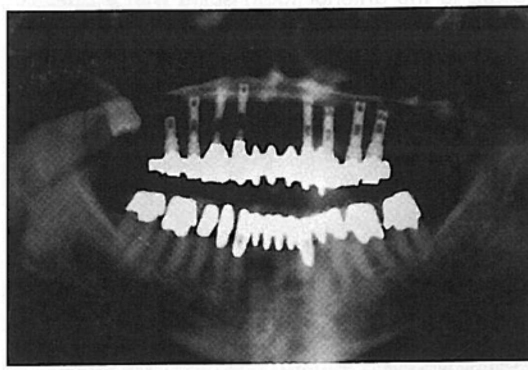

Fig 2c Radiograph of porcelain/gold tissue-integrated prosthesis with heavier framework design.

Diagnostic forecasting

Fixture support ratio

A similar condition was experienced with a 73-year-old patient who presented with a loose maxillary denture and an inability to tolerate this removable prosthesis. During the initial clinical examination, four areas of dehiscence were noted over the cover screws of fixtures previously placed. The existing removable complete denture had been reinforced with a chrome framework. This should have been an indication of the severity of her bruxing and clenching habit as well as potential future problems.

The patient's dental appearance was satisfactory and in harmony with her facial features. Clinical profile view and lateral cephalometric film analysis indicated appropriate lip support provided by the interim removable prosthesis.

Treatment planning provided for a change in the fixture support ratio with additional fixture placement for maximal load distribution to the maxillary bone. The need for the placement of four additional fixtures can be seen in Fig 2a.

A 6-month healing period was permitted before stage 2 surgery. At the abutment connection, the short 7-mm fixture in the maxillary right posterior quadrant was lost.

The traditional Brånemark prosthesis was fraught with maintenance problems over the 2-year period that this prosthesis was in place (Fig 2b). Chronic fracture of the canines and premolars occurred. With continued stability of the osseointegrated fixtures, this prosthesis was then replaced with a porcelain-fused-to-gold bone-anchored restoration. Figure 2c illustrates the framework design for the porcelain-fused-to-gold tissue-integrated prosthesis with heavier framework construction. For patients with heavy occlusal function, the porcelain-fused-to-gold bone-anchored prosthesis provides more durable function.

High stress personality

Periodontally compromised teeth

One month following the placement of the final porcelain-fused-to-gold prosthesis, the patient

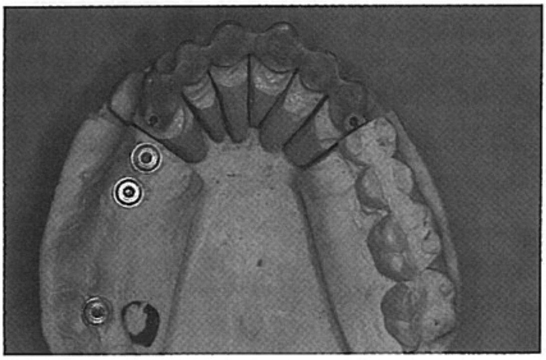

Fig 3a The three fixtures illustrated on the working cast supported a tissue-integrated prosthesis connected to the anterior tooth splint with a precision attachment.

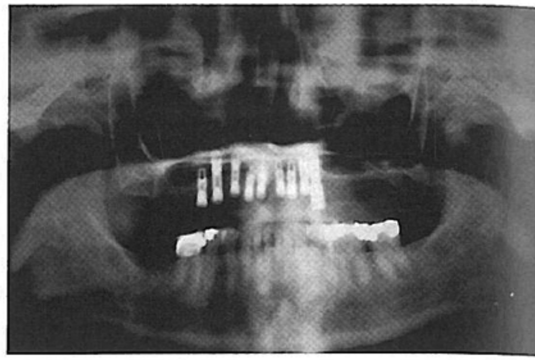

Fig 3b Removal of the maxillary anterior teeth was followed by the placement of Brånemark fixtures.

Fig 3c Abutment connection following an 8-month healing period.

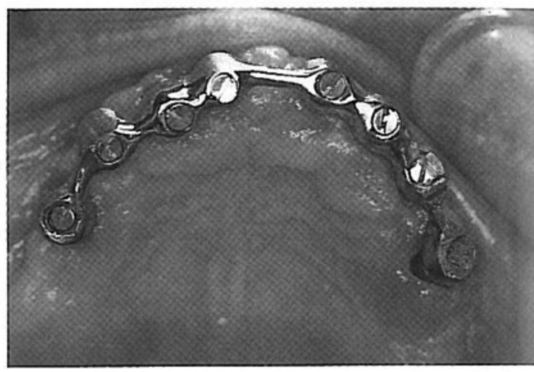

Fig 3d Gold clip-bar splints eight maxillary fixtures.

complained of discomfort in the maxillary posterior area (Fig 3a). Following clinical reevaluation and retrieval of the tissue-integrated prosthesis, the most posterior fixture exhibited clinical mobility and was no longer osseointegrated. The prosthesis was modified by removing the most posterior abutment. During the following 6-month period, a second fixture was lost to functional overload. The decision was then made to use a provisional removable partial denture to replace the missing posterior dentition. The concept of sinus lift grafting procedures was suggested to the patient. The six splinted anterior teeth continued to exhibit anterior-posterior mobility. The patient rejected the recommendation for bone grafting in the sinus areas and elected instead to have the mobile anterior teeth removed and additional fixtures placed (Fig 3b). Now with eight osseointegrated fixtures, the prosthetic treatment plan called for a gradual loading process to permit additional bone remodeling around these fixtures.

An 8-month healing time was permitted to elapse before the stage 2 surgery was performed. Following the abutment connection (Fig 3c), a non-fixture-retentive overdenture was fabricated to minimize loading of the newly uncovered fixtures. In addition, direct occlusal

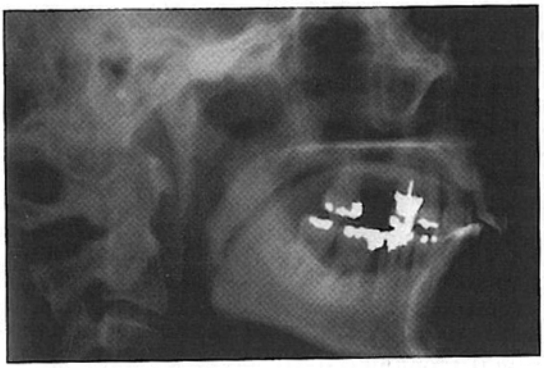

Fig 4a Lateral cephalometric radiograph demonstrates Class II relationship.

Fig 4b Lateral cephalometric radiograph illustrates maintenance of the patient's profile following removal of all the maxillary teeth.

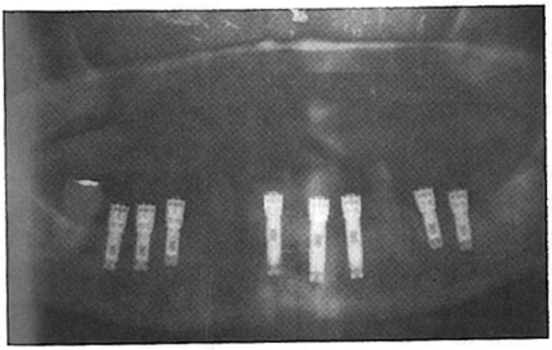

Fig 4c Fixtures placed between periodontally compromised teeth.

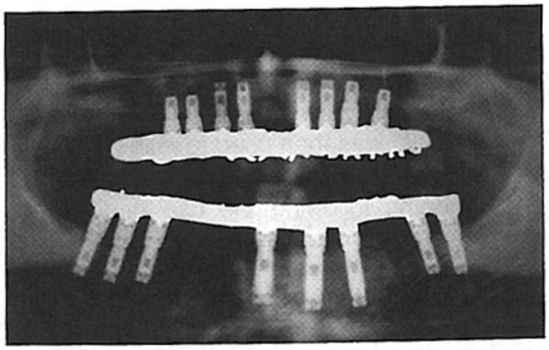

Fig 4d Both maxillary and mandibular arches were restored with traditional Brånemark fixed tissue-integrated prostheses.

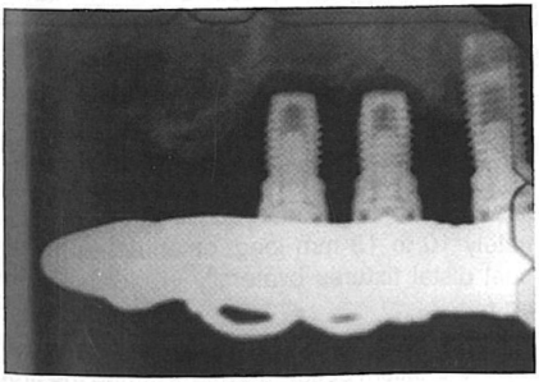

Fig 4e Radiograph of right side illustrating loss of integration around 7-mm fixtures.

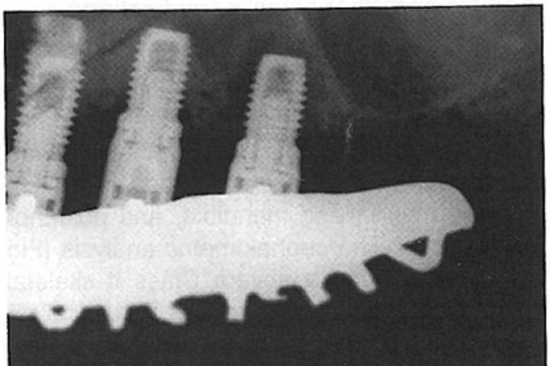

Fig 4f The radiograph from the left side illustrating the loss of integration around the last fixture.

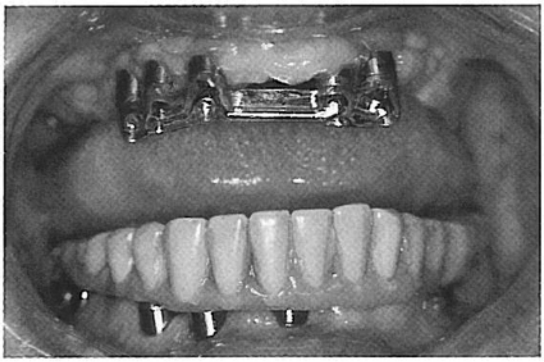

Fig 4g Gold clip-bar supported by five fixtures.

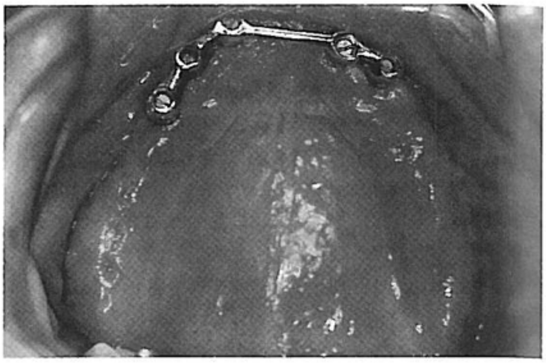

Fig 4h Inflamed residual ridge area resulting from intense occlusal loading.

loading was eliminated. This was accomplished by using dead soft wax placed in the denture to assure contact avoidance between the implants and the hard denture base. A resilient denture base material was then used to reline the overdenture prosthesis.

Six months following the use of the nonretentive overdenture, a gold clip-bar (Fig 3d) was fabricated, splinting the eight fixtures for improved load distribution. The modified overdenture had modest implant-provided retention and transmitted loading forces to the fixture. However, incorporation of the clip itself was postponed for an additional 6 months.

Biologic and mechanical complications attributed to parafunction

A clinical example illustrating biologic and mechanical complications stemming from parafunctional habits was demonstrated by a young woman with severe generalized periodontitis in both the maxilla and mandible, and posterior bite collapse. The cephalometric analysis (Fig 4a), demonstrated a severe Class II skeletal relationship with a deep overbite. Periapical radiographs confirmed the 60% to 70% generalized bone loss around the remaining teeth.

Following removal of all the periodontally involved teeth in the maxilla, the patient was provided with an interim denture to maintain esthetic lip and muscle support.[6,7] This prosthesis provided only limited function. The lateral cephalometric film shows the patient totally edentulous in the maxilla and partially edentulous in the mandible, with maintenance of her soft tissue profile (Fig 4b).

The three remaining mandibular periodontally compromised teeth were used to support a provisional restoration following the Class III modification of the Brånemark method for treatment.[4] Eight Brånemark fixtures were surgically placed between these abutment teeth (Fig 4c).

A new provisional overdenture for the maxillary arch was designed to develop a Class I occlusal scheme. With the fabrication of the final tissue-integrated prosthesis in the mandible and a new maxillary denture, a Class I occlusal relationship was finally established.

The maxillary arch had eight fixtures placed and was reconstructed using the traditional Brånemark bone-anchored prosthesis (Fig 4d). Adequate lip support and dental esthetics were established. Traditional cantilevers, approximately 10 to 13 mm long, extended from the most distal fixtures bilaterally in the maxillary arch.

Mechanical complications related to clenching and bruxism became evident during the first year following delivery of the maxillary fixed prosthesis. The patient presented on several occasions with fractures of the prosthetic materials, most often in the posterior areas.

The occlusal scheme established provided canine guidance in lateral excursion and incisor guidance in protrusion. Biologic complications were noted 1 1/2 years following the delivery of the final prosthesis. The patient then returned with sensitivity bilaterally in the maxillary posterior area. Periapical radiographs indicated that the two most distal 7-mm fixtures on the right side (Fig 4e) and the last 7-mm fixture on the left side were no longer osseointegrated (Fig 4f). This was most likely the result of the patient's intense occlusal loading pattern, which destroyed the bone/implant interface, allowing epithelial migration between the implant and the bone.

The five remaining fixtures were determined to be inadequate to support a fixed prosthesis. A gold clip-bar was then fabricated to splint the remaining fixtures for maximum removable prosthesis (Fig 4g). This overdenture, with a retention clip, was planned for use during the next 6 to 12 months. One month following delivery of this removable implant-supported prosthesis, the inflamed palatal tissues were clinically evident (Fig 4h). Comparing these tissues to the previously healthy mucosal tissues confirmed the intense occlusal loading produced by the patient.

Conclusion

In summary, gradual implant loading and progressive bone remodeling for osseointegrated implant patients is an important consideration when parafunctional habits are recognized. The time sequence suggested in the time-frame guidelines provides a simple guide. Each patient's individual occlusal force patterns must be assessed in relationship to the quality and quantity of bone and the number and distribution of osseointegrated fixtures. Management of patients with parafunctional habits can be accomplished with osseointegrated fixtures. However, their treatment plans must include long time periods producing gradual implant loading. This will enable the adjacent bone to remodel and/or the implant/bone interface to strengthen.

Parafunctional occlusal patterns are not always evident at the diagnostic stage or even early in the prosthetic treatment program. The earlier these patterns are noted, the better the opportunity to modify the tissue-integrated prosthesis to establish a more gradual loading environment.

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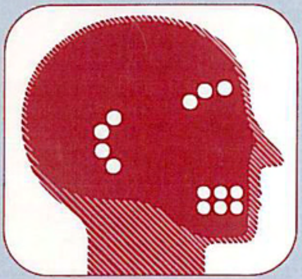

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