Limitations for tooth and implant support in fixed bridges

Dan Lundgren

Ett avsevärt reducerat men friskt parodontium kring brostöden hos en tandburen fullbro är ofta tillräckligt för att ge bron en god prognos om stöden är fördelaktigt placerade. Faktorer som kan äventyra prognosen för en sådan konstruktion är, förutom bristande plackkontroll, otillräcklig retention av brostödens kronor eller så intensiv ocklusal aktivitet att parodontiet irreversibelt traumatiseras. Multipla friändsled behöver inte äventyra prognosen hos en fullbro men förutsätter speciell omsorg beträffande dimensionering, ocklusion och kronretention. Fyra väl fördelade implantat i ben med god kvalitet ger fullbroar med posteriora, bilaterala, dubbla friändsled en god långtidsprognos. Fristående sektionsbroar stödda av minst två implantat i ben av god kvalitet visar också god prognos. Även sektionsbroar stödda av en tand och ett implantat visar hög lyckandefrekvens också när de är försedda med ett friändsled. Enstaka implantat kan även utnyttjas för att stabilisera överrörliga tänder och överrörliga tandstödda broar.

Dentitions with extremely advanced periodontal disease have often lost or are in a stage of loosing several teeth. Generally, these dentitions therefore have a great need for both adequate cause-related periodontal therapy and relevant prosthetic rehabilitation to restore function and aesthetics. A successful periodontal treatment will resolve the inflammatory lesions and arrest the periodontal breakdown around the remaining teeth. Opinions still differ, however, about how the prosthetic restoration should be designed, i.e. what type of prosthetic construction will give the best long-term results. The different standpoints are usually related to how much occlusal loading a reduced but healthy periodontium is considered to be able to withstand.

The capacity of an osseointegrated implant to withstand occlusal loading is also a matter subject to different opinions. This is reflected in the varying preconditions for implant treatment used by different clinicians. The main reasons for these differences are probably lack of systematic long-term documentation and varying clinical experience of the treatment outcome among clinicians performing implant dentistry.

The purpose of this paper is to present and discuss data which indicate where the lower limits for the amount of periodontal support for teeth and bone support for implants might be placed and still result in an acceptable or good long-term prognosis. Some cases are also presented to illustrate the clinical benefits of fully utilizing the capacity of the periodontium as well as of the osseointegrated implant. It should be observed that effective utilization of these capacities must not be confused with an unconcerned broadening of indication areas unsupported by scientific documentation and relevant clinical experience. Any therapeutic option should, together with the

Author

Dan Lundgren, LDS, Odont Dr, Associate Professor, Institute for Postgraduate Dental Education, Jönköping, and Adjunct Professor, Department of Biomaterials/ Handicap Research, Institute for Surgical Sciences, Faculty of Medicine, Göteborg University, Göteborg, Sweden.

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patient, be balanced against alternative treatment modalities regarding risks and cost–benefit ratios.

Tooth-supported fixed bridges

The capacity of the periodontium

It has been claimed in the dental literature that the amount of periodontal tissue needed to carry a tooth-supported fixed bridge should be at least equal to the amount of periodontal tissue to be replaced. However, this "law of Ante" [1] with its "one to one" principle is not necessarily a condition for successful treatment. Good long-term results of combined periodontal and prosthetic treatments comprising fixed tooth-supported bridges in dentitions with periodontal destructions far beyond what is acceptable to meet the demands of Ante´s law have in fact been documented in the literature [2–6].

Fixed cross-arch bridges with end-abutments

It has been questioned whether teeth with a markedly reduced amount of periodontal tissue supporting extensive bridges are subjected to occlusal forces of "normal" magnitude or if they are "protected" against undue occlusal forces because of peripheral receptor influences. These influences would reduce the magnitude and frequency of the occlusal forces, thereby influencing jaw-closing and chewing behaviour. By utilizing force transducers built in to the prosthetic constructions [7], it has, however, been shown that fixed cross-arch bridges with extremely reduced but favourably distributed periodontal support (*i*) can withstand occlusal forces of "normal" magnitude, and (*ii*) do not decisively influence the jaw-closing and chewing pattern. It should be observed that all individuals included in the investigations referred to exhibited excellent plaque control and none showed excessive parafunctional activities during the follow-up period.

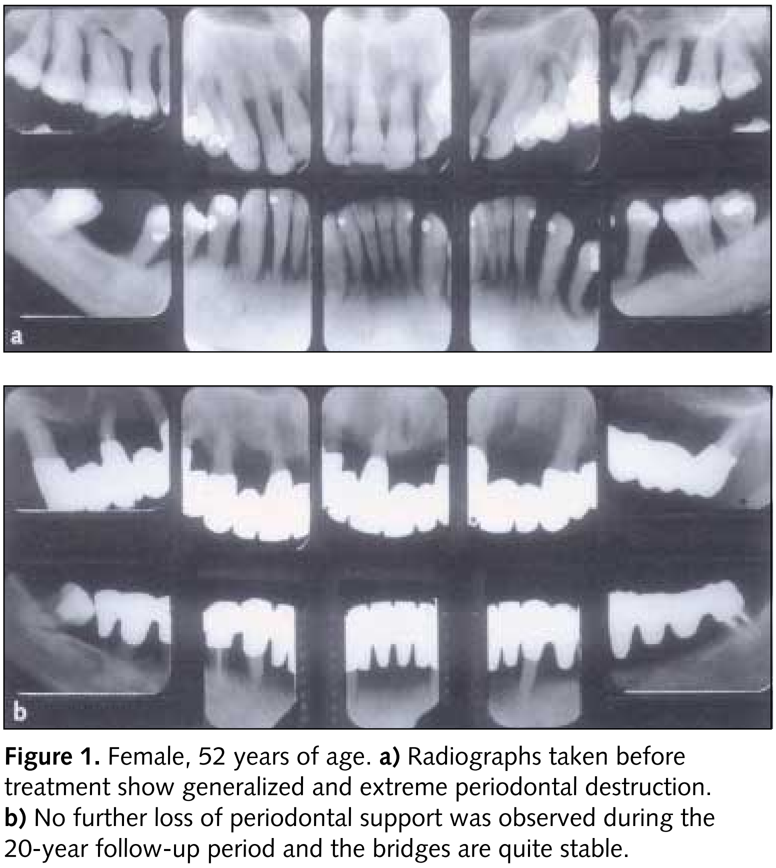

Figure 1. Female, 52 years of age. **a)** Radiographs taken before treatment show generalized and extreme periodontal destruction. **b)** No further loss of periodontal support was observed during the 20-year follow-up period and the bridges are quite stable.

The case shown in Fig. 1 illustrates the successful long-term result of combined periodontal and prosthetic treatment of a dentition with extremely reduced periodontal support. A female, 52 years of age at the start of the treatment 23 years ago, was referred to the author for "best possible treatment". She had a strong desire to avoid removable prostheses. The advanced periodontal destruction around most of the teeth was accompanied by extensive gingival recession. In fact, not more than 10%–20% of the surface of the original periodontium remained, as seen in the full-mouth radiographic documentation (Fig. 1a).

The case presentation comprised information to the patient about the extreme periodontal destruction and the causative factors. The need for multiple tooth extractions and periodontal treatment of the remaining teeth as well as for fabrication of cross-arch bridges was explained. Also the importance of adequate daily plaque control of high standard was emphasized as were the risks of biological and technical failures. Alternative treatment modalities including removable prostheses were given a low priority by the patient. Recall appointments were carried out once a year. The patient´s compliance was excellent and no complications were observed apart from a somewhat too intense mechanical cleansing activity resulting in a certain loss of tooth substance in the buccal cervical area of some teeth. No loss of periodontal support was observed during the 20-year follow-up period. The result 20 years after active treatment is shown in the radiograph in Fig. 1b.

Fixed cantilevered cross-arch bridges

Another controversial topic related to fixed bridges involves indications and contraindications for cantilever extensions. Traditionally, it is recommended that cantilever units not be used with fixed tooth-supported prosthetic constructions or that their number at least be limited to one. Such recommendations have usually been anecdotally based without any support from clinically well-controlled experiments. However, some clinical investigations concerning the prognosis of extensive bridge constructions supplied with one or more cantilever units have been published. Thus, Randow et al. [8] examined the results of extensive fixed prosthodontics performed by general practitioners, in a retrospective questionnaire study. Their investigation found a technical failure rate for fixed bridges after 7 years in service amounting to 8.2% for constructions including distal end-abutment teeth, 16.1% for fixed bridges with single cantilever extensions, 33.7% for bridges with unilateral double cantilever extensions, and 44.0% for bilateral double cantilever extensions. The main causes of failure were loss of retention of the anchor crowns adjacent to the cantilever segments, followed by fracture of the construction. The frequency of failures increased substantially with time in service, especially for constructions with double cantilever pontics. In these, loss of retention was located at the abutment tooth adjacent to the cantilever segment and the fractures occurred in the beams mesial or distal to the retainer crown of the same abutment tooth.

The findings by Randow et al. [8] were confirmed in a follow-up study by Karlsson [9]. In a retrospective long-term clinical study, they examined the bridges after 14 years in service. The prosthetic treatment had been performed by private dental practitioners. The average technical failure rate was 26.0%. Fixed bridges with distal abutment support exhibited a failure rate of 11.5%, while those with cantilever extensions showed a failure rate amounting to 36.0%. The failures increased with number of cantilever units and with time in service, and the main cause was loss of retention of distal abutment crowns.

It therefore appears that the risk for failure increases markedly if a fixed cross-arch bridge is provided with cantilever units. These studies, however, did not include any close evaluation of the biotechnical quality and design of the construction, such as preparation form of the abutments and dimensioning of the bridgework. Nor was the design of the occlusal contact pattern, especially of the cantilever segments, described. In addition, it is not possible from the reported findings to establish if the patient material included subjects with excessive parafunctional activity and/or exhibited dentitions with short clinical crowns.

Nyman and Lindhe [4] found a technical failure rate of less than 8.0%, i.e. loss of retention (3.3%), fracture of bridgework (2.1%), and fracture of abutment teeth (2.4%), after 5–8 years in 159 periodontally treated patients supplied with extensive cantilever fixed bridges. During this period, no further loss of attachment had occurred. These bridges were all performed by, or under supervision of, the senior staff of the Department of Periodontology, Institute of Odontology, Göteborg University, Sweden.

Laurell et al. [6] evaluated the long-term prognosis of extensive fixed bridges with uni- or bilaterally placed 2- or 3-unit cantilevers. These constructions had all been performed by the authors, or under their supervision, as part of the overall treatment of advanced periodontal disease. The follow-up period for 34 patients (with 36 cross-arch bridges) varied between 5 and 12 years, with an average of 8 years. During this period, one bridge construction was lost due to complete periodontal breakdown after excessive occlusal trauma caused by parafunctional activities in conjunction with an extreme, psychosocial stress period for the patient. In another patient, one (vital) abutment tooth of a 12-unit bridge, supported by two abutments, was fractured. In the remaining 32 patients, the bridges continued to function acceptably. No further periodontal breakdown occurred in any of these patients and no technical failures of the bridge constructions were observed.

However, special demands were set up for the design of these constructions: (*i*) optimal retention (long and parallel surfaces) especially of the retainer crowns adjacent to the cantilever segments; (*ii*) establishment of occlusal contacts anteriorly as well as posteriorly along the entire prosthetic construction in habitual occlusion; (*iii*) an occlusal morphology guiding the occlusal forces in an apical direction, anteriorly as well as posteriorly; (*iv*) anterior-guided lateral movements with no latero- or mediotrusive contacts on the cantilever segments; and (*v*) metal framework heights of at least 5 mm and widths of 4 mm, preferably along the entire tooth arch and definitely distal and mesial to the retainer crowns adjacent to the cantilever segments.

The authors concluded that, although failures do occur, they can be kept to a minimum provided special attention is paid to retention, dimensions, and occlusal design of the bridge construction and the periodontal tissues are properly treated. Individually related follow-up recalls should include careful control of the occlusal contact pattern of the cantilever segments. The often observed, gradually developing, hard contacts on the cantilever units, due to less occlusal wear of the cantilevers than of the abutment-supported crowns, should be eliminated to avoid development of supracontacts causing a concentration of occlusal force on the cantilever segments.

The case shown in Fig. 2 illustrates the beneficial effect of the incorporation of cantilever units in fixed bridges. A male, 56 years of age at the start of the treatment 20 years ago, with extensive loss of teeth in both jaws and advanced periodontal destruction around the remaining teeth in the maxilla, was referred to the author for periodontal treatment and prosthetic reconstruction. The only teeth remaining were positioned from the right to the left cuspid in the maxilla and from the right to the left first premolar in the mandible. The maxillary, lateral incisors could not be saved, but the remaining teeth were periodontally treated and a fixed bridge was fabricated. The bridge was supplied with a minor palatal shelf and bilateral, posterior, 2-unit cantilever extensions to involve the first and second premolar areas. This cantilever arrangement with occlusal contacts along the entire tooth arch was designed to stabilize the bridge rather than jeopardize it (Fig. 2a). The patient was followed for 20 years, and there was no further loss of periodontal support and no loss of retention of abutment crowns or signs of overload (Fig. 2b).

Figure 2. Male, 56 years of age. **a)** A cross-arch bridge with bilateral, posterior 2-unit cantilever extensions and a shelf with occlusal contacts along the entire tooth-arch. **b)** Follow-up radiographs.

Fixed segment bridges

Basically, an extremely reduced periodontium may also be sufficient to support segment bridges. The periodontium of such constructions is, however, more vulnerable to overload by lateral forces since the distribution of the abutments usually is less favourable than that of horseshoe-shaped cross-arch bridges. The effect of the lateral forces may, however, vary considerably from one individual to another due to variations in the occlusal force pattern, the jaw relations, and the occlusal morphology (cuspal inclines, etc.). It should also be observed that a slight mobility of a tooth-supported bridge does not jeopardize a good prognosis unless the mobility continuously increases.

The risk of overload

As reported by Laurell et al. [6], excessive (parafunctional) occlusal activity may overload a markedly reduced periodontium supporting a fixed bridge. Signs of such activity may therefore contraindicate fabrication or jeopardize the prognosis of extreme bridges. The case shown in Fig. 3 illustrates how narrow the safety margin is between success and failure in the treatment of such patients. A female, 56 years of age, with extremely advanced periodontal disease was referred to the author with the desire that “anything possible should be done to avoid removable prostheses”. The status of the dentition at the start of the treatment 20 years ago is shown in the radiograph in Fig. 3a. Basically, the information to the patient and the treatment schedule were about the same as for the patients shown in Figs. 1 and 2. The patient´s compliance was excellent and the result 6 years after combined periodontal and prosthetic treatment comprising cross-arch bridges with bilateral, posterior cantilever extensions in both jaws is shown in Fig. 3b.

A serious complication occurred 2 years later, i.e. 8 years after active treatment. The patient appeared acute because the bridge in the mandible suddenly had become extremely hypermobile. All abutments supporting the bridge were highly mobile and the bridge had a vertical mobility close to 1 mm in the front region. The gingival tissue around the abutments was pale and firm, but bleeding from all sulci revealed that the periodontium was lacerated. The torn and extremely widened periodontal ligaments are shown in the radiographs in Fig. 3c. It was evident that the bridge had been subjected to acute overload. It appeared that this was caused by intense use of chewing gum during 2 weeks. The patient, who was a heavy smoker, had taken part in a programme to help people stop smoking and been

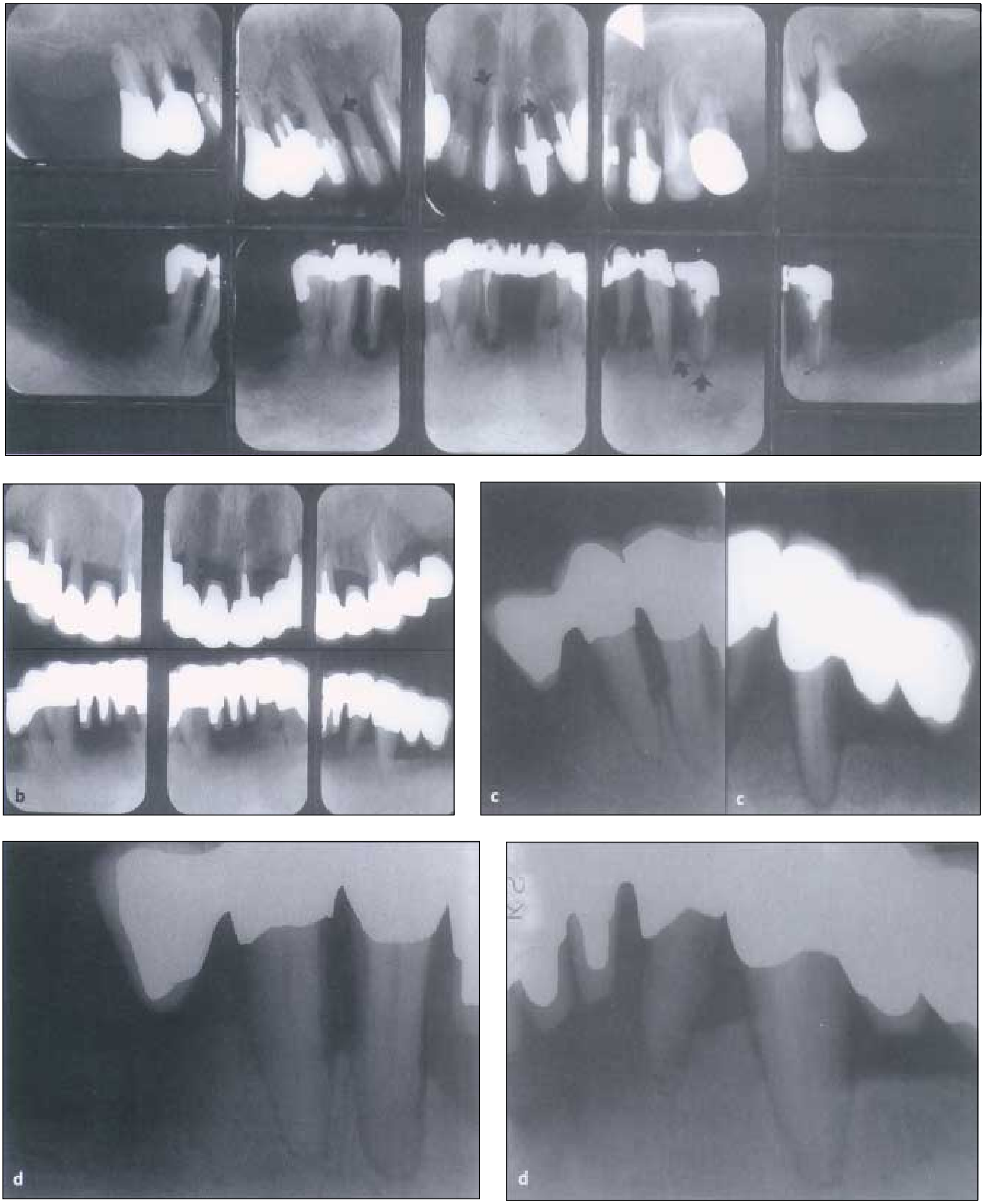

Figure 3. Female, 56 years of age. **a)** Radiographs taken before treatment. **b)** Stable cross-arch bridges with bilateral, posterior cantilever extensions in both jaws. **c)** Severely traumatized periodontium of the bridge-abutments in the mandible revealed as widened periodontal ligaments in the radiograph.
d) Narrowed periodontal ligaments indicate reconditioned periodontal tissues.

prescribed nicotine chewing gum as a substitute for smoking.

Immediate withdrawal of the chewing gum activity and prescription of soft food resulted in a decreased bridge mobility down to almost a normal level within 3 months. The regain of almost a normal width of the previously widened periodontal ligaments is shown in the radiographs in Fig. 3d.

This complication illustrates how intense occlusal activity can result in overload and cause severe periodontal trauma. It also shows, however, the remarkable capacity of the periodontium to heal and regain its original width and structure when the occlusal activity is reduced to normal levels, resulting in the re-establishment of normal mobility in hypermobile teeth.

Conclusions:

- *Dentitions successfully treated for extremely advanced periodontal disease can be restored with fixed cross-arch bridges with a good long-term prognosis.*
- *If the remaining teeth are well distributed within the jaw, only 10%–20% of the original amount of periodontal tissue might be sufficient to support such a cross-arch bridge.*
- *Cross-arch bridges with cantilevers can be used with a high rate of long-term success provided the supporting periodontal tissues are kept healthy, the occlusion and dimensioning of the bridge is adequate, and the retention of the abutment crowns is optimal.*
- *In certain situations cantilever extensions will contribute to the stability of the occlusion rather than jeopardize the prosthetic construction.*
- *High demands must be placed on the clinician responsible for the type of treatment discussed as well as on the patient to perform daily, high-quality plaque control and to understand the risks involved in this type of therapy.*
- *Excessive occlusal activity is a risk factor, which should be taken into account when considering the prognosis for prosthetic constructions on extremely reduced periodontal tissue support.*

Implant-supported fixed bridges

The capacity of osseointegrated implants

The critical number, distribution, and bony support of endosseous implants for carrying fixed bridges with good long-term prognosis have not been as thoroughly investigated as have the number of teeth and the amount and distribution of periodontal support needed for tooth-anchored bridges. The obtained surface of bone-to-implant contact is dependent on the area of the surface of the implant and the density of the surrounding bone, i.e. of bone quantity and quality. The total contact surface needed to carry a bridge with good prognosis depends not only on the distribution of the implants in relation to the extension of the bridge but also on the magnitude, intensity, and direction of the occlusal forces that will load the bridge. This is, in turn, a consequence of the inherent occlusal force pattern of each individual and the relations between the jaws, both factors which can vary considerably. Also, the location of the bridge within the tooth-arch and its occlusal morphology will influence the loading of the implants.

Fixed cross-arch bridges

Traditionally, fixed cross-arch bridges are supported by osseointegrated implants placed anterior to the mental foraminae and the sinus cavities. This means that such bridges usually are supplied with posterior bilateral 2-unit cantilevers to comprise the first and second premolar areas. The long-term results of restoration with this type of bridge are extremely good if the bone quality is favourable. They also confirm the high success rate of using posterior 2-unit cantilevers in general, as previously discussed. Although 5–6 implants usually are used, published data show that four favourably distributed implants may be enough to ensure long-term maintenance provided the bone quality is sufficient [10]. A minimum length of 10 mm is advocated for each implant, although shorter implants have also been successfully used.

It has been shown that the magnitude of the occlusal forces and the force distribution are about the same for implant-supported as for tooth-supported bridges [11]. Thus, the occlusal forces are much smaller in the anterior than in the posterior area of the jaw during jaw-closing in habitual occlusion. Basically, the front section of an end-supported cross-arch bridge (or a front bridge) therefore is subjected to smaller forces than the premolar-molar section of the bridge during biting in habitual occlusion, provided the hardness of the occlusal contacts is equal along the entire tooth-arch. Bridges supplied with (at least 2) posterior cantilever units are, however, usually subjected to smaller forces on its second cantilever unit due to its apical deflection when loaded. Furthermore, in a dentition with anterior guidance there will be only minor forces on the posterior section of the bridge, since the teeth in this area will disocclude during excursions of the mandible. Low cuspal inclines in the posterior areas will further reduce the lateral forces during mandible excursions.

The distribution of the occlusal forces can to a considerable degree be actively controlled. Thus, certain occlusal units can be arranged to have slight contacts or be placed in an inferior position in relation to other units and the antagonistic teeth. This means, for instance, that posterior cantilever units can be adjusted to carry a minimum of force also in the habitual occlusion. The occlusal forces will then be concentrated to the implant-supported anterior area of the bridge [12]. Such a force distribution will also reduce the overall area of bone-to-implant contact surface needed.

The distribution of occlusal forces during chewing is basically the same as during maximal biting but the magnitude of the forces is much smaller. The effect of the bolus placement on the local concentration of forces to an implant is dependent on the chewing pattern and the consistency of the food.

Fixed segment bridges

There are no studies published which systematically have explored the smallest number, length, and diameter needed for implants to carry free-standing segment bridges. Cases are known, though, where two implants have carried free-standing 3–4-unit bridges for 10 years or more, both in the maxilla and mandible, without any signs of excessive breakdown of marginal alveolar bone or loss of osseointegration or fatigue fractures of the implant components. It has, however, been suggested that, when possible, three (irregularly placed) rather than two implants should be aimed at to support any segment bridge [13], the reason being that the resistance to lateral forces will increase and the risk of the prosthetic screws loosening will be minimized. It may, however, be argued that three implants in good bone to support a minor (3-unit) segment bridge are needed only in cases where undue force activities might be expected.

It is advisable that segment bridges, supported by implants with a small bone-to-implant surface, are relieved from load by intentional distribution of occlusal forces to areas with natural teeth. This may be achieved if the implant-supported segment bridge is given slight contacts or is placed in an infraoccluded position in relation to the adjacent teeth. This will reduce the effect not only of the biting forces but also, to a considerable degree, of the chewing forces on the implants [12]. The long-term effect of such an infraocclusion presupposes that the antagonizing units do not spontaneously elongate or are prevented from elongation.

The risk of overload

It is evident from what has been discussed that the lower limits for the amount of implant-support in fixed bridges are dependent not only on the bone quantity and quality (density) but also on the patient´s occlusal force pattern and the possibilities to favourably arrange the occlusion. Thus, patients with signs of excessive parafunctional (clenching and bruxing) habits should be supplied with a considerable safety margin regarding the total surface of implant-to-bone contact. This is especially important since it is more critical to avoid overload of an implant than of a tooth; the capacity of an overloaded implant to regain lost osseointegration is smaller than is the capacity of an overloaded tooth to regain a normal periodontium.

Fixed bridges with mixed support

It is well known that the mobility of an implant is much smaller than that of a tooth for the same force magnitude due to the firmer anchorage of the implant to the jaw bone. It is therefore suggested that if an implant and a tooth are "stiffly" united by a fixed bridge there will be a concentration of occlusal forces on the less yielding implant. Several factors, however, will also contribute to a considerable force distribution to the natural tooth when the tooth-supported part of such a bridge is loaded. One is the lateral tilting of the implant when the loaded tooth is intruded into its socket. This tilting is directly transferred via the bridge-beam to the tooth, which then will reach the bottom of the socket and give rise to a counterforce. The degree of implant-tilting is due to the elasticity of the jaw bone and the lateral bending of the screw-joints between the implant-abutment-crown units. Another factor that will contribute to force-uptake by the tooth is the bending of the bridge-beam when the tooth is loaded. Taken together, these factors mean that even small occlusal forces acting on the tooth-supported part of the bridge will apically displace the tooth to reach the bottom (and/or the lateral wall) of the tooth socket. The tooth will then be able to produce counterforces of about the same magnitude as the implant.

The longer the distance between the implant and the tooth and the more flexible the beam, the larger the relative uptake of force by the tooth and the smaller the lateral bending forces on the

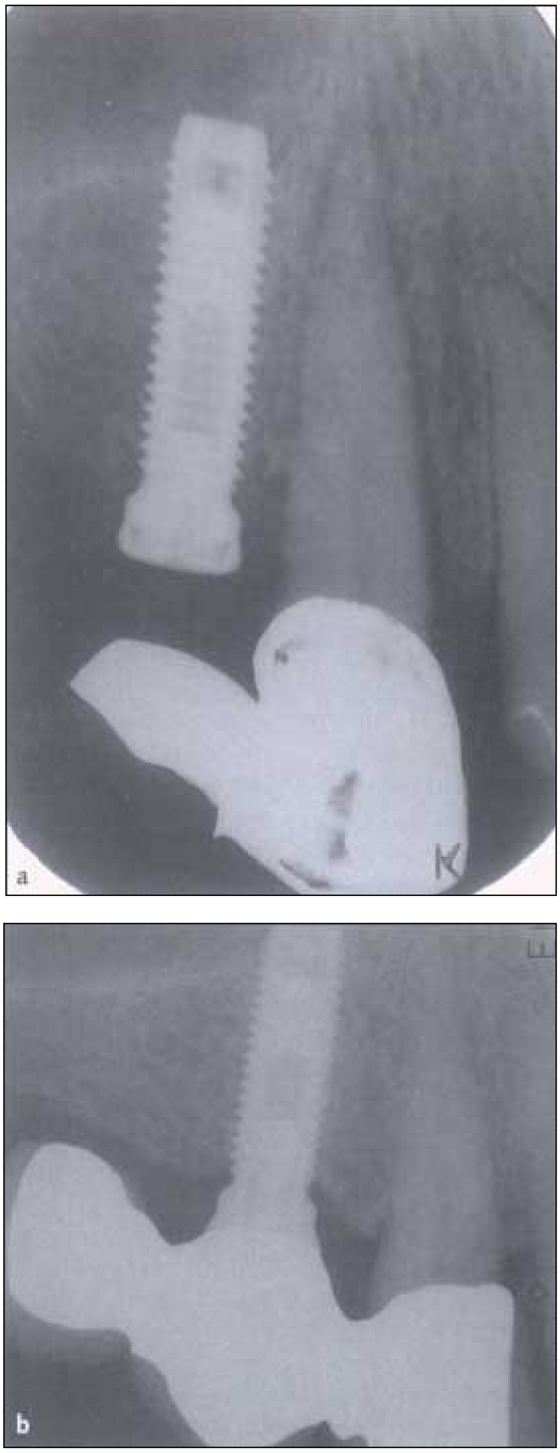

Figure 4.
a) Radiographs with hypermobile (grade 2) maxillary right cuspid at the insertion of an implant immediately distal to the cuspid.
b) The same tooth 3 months after delivery of a fixed cantilevered bridge supported on the cuspid and the implant. The cuspid has now regained a periodontium of normal width and has a normal mobility.

implant. It would therefore seem logical that in a fixed bridge with mixed support the implant should have a higher success rate the longer the distance between the implant and the tooth. It has, however, been shown that fixed bridges supported by a combination of implants and teeth, will function satisfactorily for a long time also when the distance between the two units is comparatively short, for example comprises the width of only one pontic [14].

It has also been shown [15] that fixed bridges with mixed support where the tooth and the implant are located next to each other (i.e. without any intervening pontic) have a good long-term prognosis. Thus, a series of patients supplied with 3-unit bridges supported by the right or left maxillary cuspid and an implant placed immediately distal to the cuspid and supplied with a cantilever unit distal to the implant has been followed for 5 years. The results show 100% survival of both implants and teeth with no measurable loss of supporting periodontium around the teeth or supporting bone around the implants. There are several factors that may explain the high success rate of this treatment modality. One is that a single implant in the anterior region, where the occlusal forces are comparatively small, can also withstand the forces transmitted via bilateral cantilevers (the cuspid is then considered to be suspended in a mesial cantilever of the implant). Another factor is that the cuspid regulates the occlusal forces via its periodontal mechanoreceptors. A third possibility is that the lateral tilting of the implant is sufficient to cause at least some of the forces to be taken up by the cuspid.

The probability that the first alternative plays a central role is supported by the fact that an osseointegrated implant in this area can also be used to stabilize a hypermobile tooth, the periodontium of which then rapidly will be reorganized and narrowed resulting in a conversion from highly increased to normal tooth mobility. This is illustrated in the radiographs in Fig. 4 showing a hypermobile (grade 2) right maxillary cuspid at the insertion of an implant immediately distal to the cuspid (Fig. 4a) and the same tooth 3 months after delivery of a fixed cantilevered bridge supported by the cuspid and the implant (Fig. 4b). The cuspid has now regained a periodontium of normal width and has normal mobility.

The force-withstanding capacity of an osseointegrated implant is further elucidated by the fact that a single implant may even be used to successfully stabilize hypermobile, tooth-supported bridges. A case shown in Fig. 5 illustrates the long-term result of such a treatment. A male, 50 years of age, had an extremely hypermobile mandibular cross-arch bridge, supported by the cuspids and the second premolars. The cuspids, especially, had a markedly reduced periodontal support. The entire bridge was extremely hypermobile with a vertical mobility of about 1 mm in the front region. Without removing the bridge, installation of a Brånemark implant was undertaken in the incisor area to stabilize the bridge with a screw connection. Fig. 5a shows the connection of the installed implant to the bridge. The hypermobility of the bridge was rapidly reduced to reach normal mobility within 3 months. The status of the right and left cuspids before and 8 years after the implant-bridge connection is shown in Figs. 5b and c.

It should be emphasized that, as for solely tooth-supported bridges, the clinician should also strive for the best possible safety margin to obtain a good long-term prognosis for implant-supported bridges, whether free-standing or partially supported by teeth. The treatment results from the cases shown in this article indicate, however, that properly utilized osseointegrated implants also seem to have a hitherto unknown capacity to support natural teeth and tooth-supported bridges with good long-term prognosis. A successful outcome presupposes, however, a careful diagnosis and consideration not only of bone quality (density) and quantity but also of occlusal factors.

Conclusions:

- *Four favourably distributed implants are sufficient to carry cross-arch bridges with posterior, bilateral 2-unit cantilevers provided the bone quality (density) and quantity are adequate for each implant.*
- *Two implants can carry 3–4-unit, free-standing segment bridges.*
- *One implant can, together with a tooth, carry a 3-unit bridge, even when the bridge has a cantilever unit next to the implant.*
- *One implant can be used to stabilize a hypermobile tooth or a hypermobile tooth-supported bridge to re-establish normal tooth or bridge mobility.*
- *The total area of bone-to-implant contact needed to successfully support a fixed bridge is dependent on many factors such as occlusal force pattern, jaw relations, occlusal morphology, etc. This emphasizes the necessity of proper individual diagnosis and treatment planning.*

Figure 5. Male, 50 years of age, with an extremely hypermobile mandibular cross-arch bridge. **a)** The connection to the bridge of an installed implant. The hypermobility of the bridge was rapidly reduced to reach normal mobility within 3 months. **b, c)** Radiographs showing the periodontal support of the right and left cuspid abutments before *(b)* and 8 years after *(c)* the implant-bridge connection.

Summary

Limitations for tooth and implant support in fixed bridges

A markedly reduced amount of healthy and well distributed periodontal tissue is often sufficient to carry fixed, tooth-supported cross-arch bridges with good long-term prognosis. There are, however, factors which may contraindicate fabrication or jeopardize the prognosis of such constructions. These factors are insufficient plaque control, inadequate retention of abutment crowns, and extremely intense occlusal activities (parafunctions) that may overload the supporting periodontium. Multiple cantilever units do not jeopardize the prognosis of cross-arch bridges provided occlusion, beam-dimensioning, and retention of anchor crowns are adequate. A tooth-supported segment bridge with extremely reduced periodontium is usually more vulnerable to lateral forces than a cross-arch bridge due to more unfavourable distribution of the abutments. The risk of (increasing) bridge hypermobility can, however, be reduced by modified occlusion.

With implant-supported fixed bridges little is known about the least amount of supporting bone needed for sufficient long-term function. Four well-distributed implants anchored in bone of good quality are sufficient to give a good long-term prognosis of cross-arch bridges with posterior 2-unit cantilever extensions. Free-standing segment bridges supported by at least two implants anchored in bone of high quality also have a good prognosis. Even segment bridges, supported by one implant and one tooth, have been shown to function satisfactorily for a long time, also when supplied with a cantilever unit. In fact, single implants may even be used to successfully stabilize and re-establish normal mobility of hypermobile teeth and hypermobile tooth-supported bridges.

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Address

Dan Lundgren, Department of Biomaterials/Handicap Research, Institute for Surgical Sciences, Göteborg University, Box 412, SE-405 30 Göteborg, Sweden.

Erratum

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