

## A 30-Year Follow-Up of a Patient with Mandibular Complete-Arch Fixed Implant-Supported Prosthesis on 4 Implants: A Clinical Report

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### Abstract

Mandibular complete-arch fixed implant-supported prostheses are recognized as one of the earliest and most popular prostheses in implant dentistry. This prosthesis was the main focus in the early era of osseointegration. Despite its widespread popularity, few clinical reports have described long-term follow-up greater than 10 years for this type of prosthesis. This report describes a 30-year follow-up of a patient who underwent treatment for a mandibular complete-arch fixed implant-supported prosthesis with 4 machined surfaced implants, opposing a maxillary complete denture. This report documents a variety of photographs and radiographs taken over a period of 30 years to compare bone levels at various stages of care and maintenance, including de novo bone formation underneath the distal cantilevers due to functional loading. The biologic and biomechanical response to this treatment protocol and long-term clinical observations and prosthodontic outcome and maintenance needs are also addressed.

Prosthodontic rehabilitation changed forever after the discovery and application of the concept of osseointegration by a Swedish physician, Per Ingvar Branemark, in 1960s.<sup>1</sup> He defined osseointegration as the direct contact of an alloplastic titanium prosthesis (which he called a “fixture”) with living bone under functional loading, as visualized under a light microscope.<sup>1</sup> Following decades of continued clinical research, Branemark’s treatment concept was no longer considered experimental by the dental community.<sup>2-5</sup> However, it was not without a degree of skepticism that the dental profession was slow to embrace this new treatment modality. Previous implant experiments were wrought with infection, extensive bone loss, pain, poor mastication and ultimately, failure with removal of the offending implants.<sup>5</sup> Nonetheless, with careful execution of Branemark’s prescribed surgical and prosthodontic protocols, clinicians were beginning to experience a high degree of implant survival.

Branemark’s initial focus on use of dental implants was restricted to edentulous patients, specifically patients with extremely resorbed mandibles. This was because many long-term edentulous patients had moderately accommodated to their maxillary denture, but the resorbed mandible, due to its

relationship to the floor of the mouth, tongue, and labial vestibule significantly affected the patient’s quality of life.<sup>6</sup> Additionally, many edentulous patients had previously unsuccessful mandibular vestibular extension surgery. Therefore, Branemark recognized the immediate impact his dental implants and osseointegration concept had on patients with edentulous mandibles, when the implants were functionally loaded. Branemark’s initial protocol called for placement of 5 to 6 axially inclined implants in the interforamen region of the mandible.<sup>6</sup> This surgery required a vestibular incision under a hospital operating room setting using a sterile protocol. All surgeries were 2-stage surgeries with a healing period of 4 to 6 months between implant placement and uncovering.<sup>6</sup>

The implants initially produced for the Branemark System were a visually smooth surface, now often referred to as the original “machined” or “turned” surface implant, with an external hex to aid in insertion of the implant itself, as well as the connection of a trans-mucosal abutment. The actual height of the abutment itself ranged from 3.0 to 7.0 mm in order to accommodate various soft tissue thicknesses.<sup>7</sup> Branemark and his team systematically treated several hundred patients from

the mid-1960s up to the 1980s and published data spanning up to 15 years to document the longevity of their treatment success.<sup>8</sup> Since then, numerous studies around the world have replicated their findings.<sup>9-11</sup> Nevertheless, few clinical reports exist to describe long-term follow-up greater than 10 years for this type of prosthesis. Only a few clinical reports have described follow-up of 20 to 30 years of patients with dental implants.<sup>12,13</sup> Therefore, the purpose of this article is to describe a 30-year follow-up of a patient who underwent treatment for a mandibular complete-arch fixed implant-supported prosthesis with 4 machined surfaced implants opposing a maxillary complete denture. The article also reviews the biologic and biomechanical response to this treatment protocol and points out the long-term clinical observations and prosthodontic maintenance related to this popular form of implant therapy. To the authors' best knowledge, this is the first clinical report in the literature describing a 30-year follow-up of an edentulous patient rehabilitated with only 4 implants.

## Clinical report

A 53-year-old female patient presented in March 1987 with an edentulous maxilla and completely dentate mandible with advanced periodontal disease requesting solutions for her terminal teeth in the mandible (Fig 1). The clinical appearance of her crowded mandibular anterior teeth was esthetically objectionable to the patient. Her medical history was remarkable only for controlled mild hypertension. Her dental history was, however, remarkable in that she had become recently edentulous in the maxilla due to periodontal disease and presented wearing an immediate interim denture (Fig 2). Radiographically, the patient exhibited bone loss, which varied from 40 to 80%, for all mandibular teeth, evidenced by extensive bone loss and significant tooth mobility (Fig 3).

## Diagnosis and treatment plan

The patient was diagnosed with generalized aggressive periodontitis in the mandible and complete edentulism in the maxilla. After a careful analysis of the clinical situation and the patient's expectations and desires, different treatment options were presented to the patient. As the patient desired fixed prosthetic solutions for replacement of her mandibular teeth, she was treatment-planned for a screw-retained metal resin fixed prosthesis supported by 6 axially placed implants (Branemark Biotes, Gothenburg, Sweden) in the mandibular arch and a new removable complete denture to replace the maxillary dentition. Regular lifelong professional and at-home maintenance was to supplement the treatment.

## Initial treatment

The patient declined the treatment plan presented due to financial and social constraints during that time. Instead she opted to have an immediate mandibular complete denture after extraction of all her mandibular teeth. This was accomplished in May 1987, which was followed by numerous relines for the mandibular denture in the weeks following the initial procedure. In September 1987 she presented with a fractured mandibular denture at the midline, which was immediately repaired with a

heavy gauge wire and autopolymerizing acrylic resin followed by another hard reline. The patient then returned in December 1987, requesting implants in the mandibular arch to support a fixed prosthesis; however, 6 implants were not economically feasible for the patient, and a treatment decision was made to only use 4 implants to achieve the treatment goal.

## Implant surgery

Under local anesthesia, full thickness mucoperiosteal flaps were elevated in the mandible, and the mental foramina were visualized bilaterally. Careful evaluation of the anterior loop of the mental nerve was accomplished using a periodontal probe. Following Branemark's surgical protocol, 4 Biotes machine-surfaced external hex implants (13 mm long, 3.75 mm in diameter) were placed in the anterior mandible. All implants were placed immediately anterior to the mental foramina to achieve a broad distribution. All 4 implants exhibited good primary stability, and cover screws were placed on all 4 implants before the flaps were sutured for primary closure using resorbable sutures. The mandibular denture was then relined with a soft liner for the patient's comfort. The resorbable sutures were then removed 10 days later, and the patient healed uneventfully.

## Implant uncovering and prosthodontic treatment

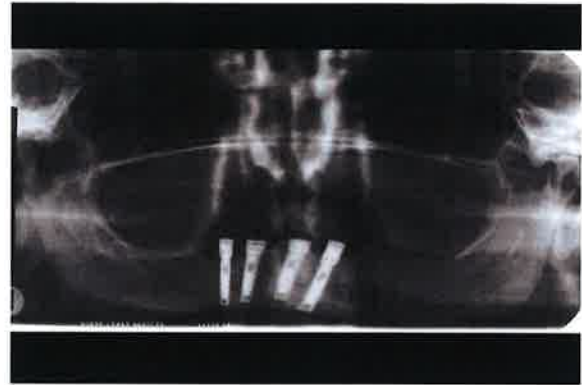
In May 1988, after a healing period of 5 months, the patient underwent a second surgery under local anesthesia, to uncover the implants and cover screws to permit the installation of the Branemark "standard" abutments. The implant in the right anterior mandible had bone covering the cover screw that required some bone resection to remove the cover screw and install the abutment. The abutment lengths from left to right were: 5.5 mm, 4.0 mm, 3.0 mm, and 7.0 mm. A panoramic radiograph was made to verify that all the abutments were fully seated on the implants (Fig 4). The flaps were then sutured, and in the absence of temporary titanium cylinders at that time, impression copings were inserted over the abutments using 15 mm guide pins. The patient's existing mandibular removable denture was then used as a conversion prosthesis. Five days later the patient returned with a fractured conversion prosthesis, which was repaired by shortening a portion of the distal cantilever. In June 1988, the final mandibular implant-supported, screw-retained fixed prosthesis consisting of a cast gold framework and acrylic resin denture teeth was delivered (Fig 5). The mucosa around the titanium abutments was completely healed and appeared healthy (Fig 6). A panoramic radiograph was made after insertion of the definitive prosthesis (Fig 7).

## Early (5-year) follow-up and professional maintenance

During the first year after insertion of the prosthesis, the patient returned every 3 months for professional biological and mechanical maintenance, and to examine the tightness of the gold prosthetic screws. A year later the hygiene scheduled was changed to every 4 months, and the year following that, the patient was scheduled every 6 months for professional maintenance. During that time, a minor prosthodontic complication occurred in late 1991 with the fracture of tooth #23, which was repaired unremarkably.



**Figure 1** Frontal image of the patient's maxillary denture and failing mandibular teeth at the time of initial presentation in March 1987.



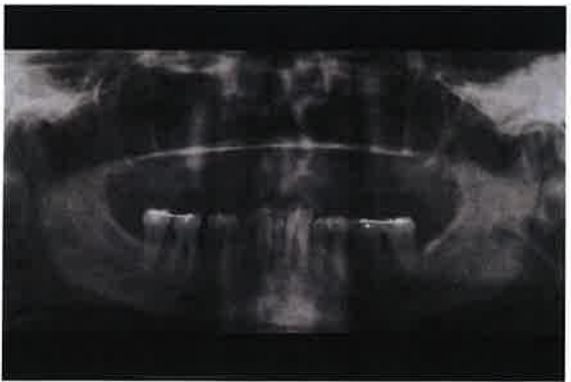
**Figure 4** Panoramic radiograph made after initial connection of the abutments to the 4 axially positioned machined surface dental implants.



**Figure 2** Frontal image of the patient's edentulous maxilla and failing mandibular teeth at the time of initial presentation in March 1987.



**Figure 5** Occlusal view of the definitive mandibular definitive metal-resin prosthesis in June 1988.



**Figure 3** Initial panoramic radiograph reveals significant bone loss, which was clinically diagnosed as chronic generalized severe periodontal disease, in the mandibular dentition.

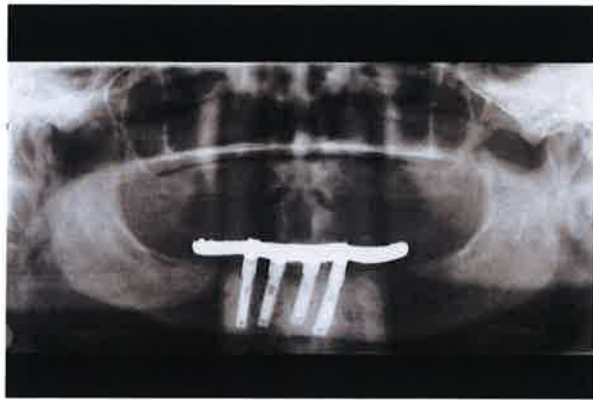


**Figure 6** Close-up image of the healed soft tissues around the 4 abutments immediately before insertion of the mandibular definitive metal-resin prosthesis.

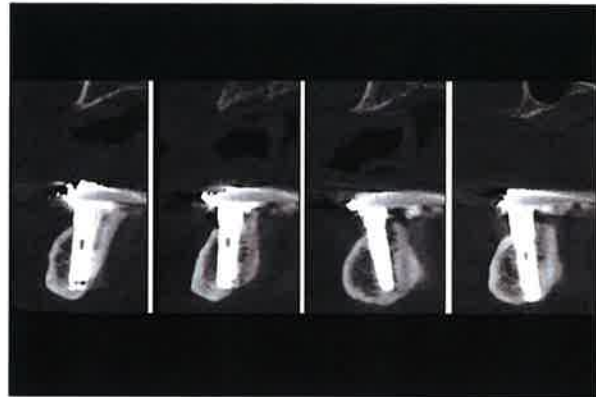
### **Late (5- to 30-year) follow-up and professional maintenance**

In 1995 during routine professional maintenance, an acrylic resin fracture line was noted, at the junction of the cantilever section with the anterior implant-supported area of the

prosthesis, but due to lack of any obvious fracture, no intervention was necessary. Five years later, in November 2000, the patient sustained yet an additional complication with teeth #20 and #24 fracturing off the prosthesis. At this stage, the patient was told that she was exhibiting significant wear of the occlusal surfaces of both the maxillary and mandibular prostheses, with



**Figure 7** Panoramic radiograph made after insertion of the mandibular definitive metal-resin prosthesis in June 1988.



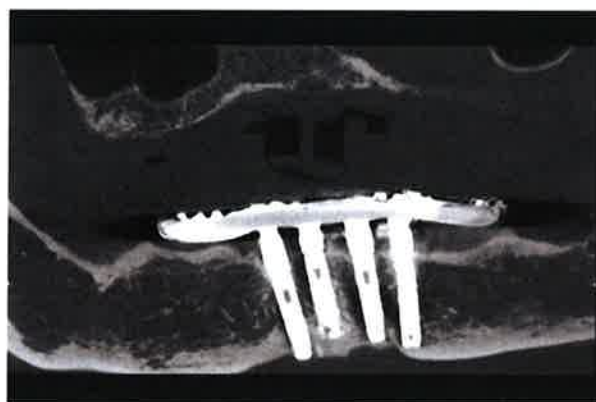
**Figure 10** Cross sectional view of CBCT image reveals excellent bone levels around all 4 machined surface dental implants.



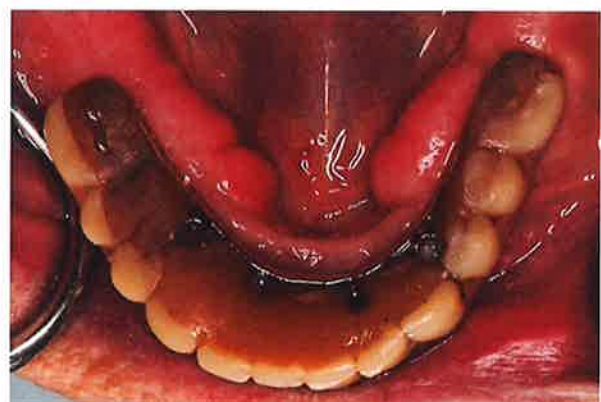
**Figure 8** Panoramic radiograph made in 2006 (9 years after implant placement) showed excellent bone levels around all implants. Also note the remarkable osteogenesis indicating new bone formation underneath the distal cantilever regions compared to Figure 7



**Figure 11** Frontal image of the patient's maxillary denture and metal-resin prosthesis made at the 30-year follow-up. The maxillary denture and a mandibular retread had been remade 17 years before. Notice the posterior open bite and compromised occlusion indicating the need for a new retread.



**Figure 9** CBCT image made in July 2017 confirmed the stability of bone around the implants as well as the osteogenic bone underneath the distal cantilever regions



**Figure 12** Occlusal view of the mandibular metal-resin prosthesis made at the 30-year follow-up shows significant wear of denture teeth indicating the need for a new retread. Notice the exposure of the gold framework.

a loss of occlusal vertical dimension. She agreed to revisional prosthodontic treatment with the fabrication of a new maxillary complete removable denture and a retread procedure of the mandibular gold framework prosthesis, by replacement with new denture teeth.

Thereafter, the patient was not systematic in her adherence to recall and professional maintenance regimen, returning sporadically in 2001, 2002, and 2006, at which time a follow-up panoramic radiograph was made. The panoramic radiograph was unremarkable for bone levels around all 4 implants; however, it showed remarkable findings for *de novo* bone formation underneath the distal cantilever regions, likely as a response to functional loading<sup>14</sup> (Fig 8).

Two years later, in September 2008, the patient returned for routine hygiene and prosthodontic follow-up. All implants remained stable, and soft tissue remained noninflamed and healthy. The patient then moved away several hundred miles to another town and presented to another clinician in July 2017 for routine follow-up. The patient admitted failing to have hygiene around the implants for 4 or 5 years at a time. Cone beam computed tomography (CBCT) images made at this visit confirmed excellent bone levels around all 4 dental implants and that the bone levels beneath the distal cantilever extensions of the prosthesis have remained consistent (Figs 9 and 10). Clinical photos from July 2017 illustrate the severity of the wear for the mandibular implant-supported prosthesis opposing the maxillary complete denture, indicating an additional loss of occlusal support, and the patient was told about the need for another maxillary complete denture and another retread of her mandibular prosthesis, which she stated she would consider in the future (Figs 11 and 12). Nevertheless, she remained extremely satisfied with her treatment outcome 30 years later and stated that she was able to “eat just about anything.”

## Discussion

The “All on 4” is one of the most popular treatment concepts in contemporary implant dentistry.<sup>9-11</sup> The rationale for using only 4 implants in the “All on 4” treatment concept is due to the adequacy of 4 modern roughened surface implants to satisfy the biomechanical requirements based on *in vitro* studies.<sup>9-11</sup> With sufficient clinical evidence supporting the fidelity of implant therapy using roughened surface implants, the risk for loss of an implant is also known to be minimal. Furthermore, using only 4 implants aids in reduction of treatment cost and aids in easier hygiene maintenance as compared to 6 implants.<sup>10,11</sup> In the present report, the patient was treated with only 4 axially placed machined surface implants to aid in treatment cost reduction. This was fewer than the 6 implants recommended by Branemark at that time.

A few long-term clinical reports have reported on the 30-year survival of mandibular complete-arch fixed implant-supported prostheses (CAFIP) on 6 implants.<sup>12,13</sup> To the authors’ knowledge this is the first clinical report documenting a 30-year follow-up using only 4 machined surface implants, which would have been considered “experimental” during the time this patient’s surgery was performed; however, radiographs taken over a 30-year period show the survival of all 4 machined surface implants with minimal bone loss, despite the

patient’s professional hygiene maintenance and sporadic daily oral hygiene attention. This depicts the phenomenal response of bone to titanium and the resiliency of bone despite inadequate professional and at-home maintenance

Surprisingly, osteogenesis due to *de novo* bone formation underneath the distal cantilever region was noticed in this patient. This observation was previously described by Taylor in 1989.<sup>14</sup> The biomechanical reasoning for this phenomenon is based on Wolff’s Law, which is defined as “principle of bone healing and/or remodeling based upon the understanding that bone remodels in response to physical stress by depositing bone in locations of increased stress and resorbing bone in areas of little or no stress.”<sup>15</sup> The stability of the mucosal tissue around each machine-surfaced abutment was also noted, even in areas where there was minimal or no attached gingiva. This finding was also observed by other authors.<sup>10,13</sup> It is likely that the soft tissue surrounding the bone also exerted a positive response to increased stress and resisted recession. This observation should be researched by future investigators.

The significant wear and abrasion of the acrylic resin denture teeth and the gingival resin as well as fracture of the resin is not unusual, as this has been well documented in the literature to be a common prosthodontic complication, irrespective of the opposing jaw prosthesis.<sup>16</sup> Use of modern digital technology and monolithic acrylic resin materials for retread of the same framework or use of modern materials such as monolithic zirconia are viable options for resolving these issues.<sup>16,17</sup> Nevertheless, it is important for patients seek lifelong routine professional maintenance to address biological and mechanical issues.<sup>18</sup>

## Conclusion

This clinical report described the diagnosis, treatment planning, surgical treatment, prosthodontic treatment, maintenance, complications, and a 30-year follow-up of a patient who underwent treatment for a mandibular complete-arch fixed implant-supported prosthesis with only 4 machined surfaced implants, opposing a maxillary complete denture. There was no loss of any implants, and the bone levels around all implants were excellent along with osteogenesis in the distal cantilever region and there were no biologic complications. The prosthodontic framework was intact, but there was continued prosthodontic complication related to the wear and fracture of acrylic resin denture teeth, which underscores the importance of patient recall and professional maintenance to ensure the optimal performance of the prosthesis.

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