# A longitudinal study of the survival of All-on-4 implants in the mandible with up to 10 years of follow-up

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## ABSTRACT

**Background.** Immediate-function implants have become an accepted alternative for fixed restoration protocols in edentulous mandibles on the basis of documented high success rates. The All-on-4 concept (Nobel Biocare, Göteborg, Sweden), a surgical and prosthetic protocol for immediate function involving the use of four implants to support a fixed prosthesis in patients with completely edentulous mandibles, represents one of these protocols. The authors conducted a study to document long-term follow-up of the All-on-4 concept.

**Methods.** This longitudinal study included 245 patients with a total of 980 immediate-function implants (four per patient), all placed in the anterior region, to support fixed full-arch mandibular prostheses. The inclusion criterion was having an edentulous mandible, or a mandible with hopeless teeth, in need of fixed implant restorations.

**Results.** A total of 21 implants failed in 13 patients, giving cumulative patient-related and implant-related success rates of 94.8 percent and 98.1 percent, respectively, at five years, and 93.8 percent and 94.8 percent, respectively, with up to 10 years of follow-up. The prostheses' survival rate was 99.2 percent with up to 10 years of follow up.

**Conclusions.** The results support the conclusion that use of the All-on-4 immediate-function implant concept in completely edentulous mandibles is viable in the long term.

**Clinical Implications.** High prosthesis survival rates can be achieved by the use of four implants to support a full-arch fixed prosthesis in the mandible.


**Key Words.** Dental implants; implant angulation; complete arch; immediate function; immediate load; mandible.

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Immediate-function protocols involving the use of implant-supported prostheses for the rehabilitation of completely edentulous mandibles are documented as having high success rates.[1-5] The placement of axial implants in immediate function for the treatment of fully edentulous patients has demonstrated to be a predictable procedure in the long term.[6-8] The loss of posterior teeth, particularly at an early age, leads to the loss of alveolar bone with a relative surfacing of the inferior alveolar nerve in the mandible, thus often prohibiting placement of implants in the posterior regions. An alternative could be the use of tilted implants, which allows for maximum use of the existing bone and placement of posterior fixed teeth with minimum cantilevers, in a region where bone height and nerve proximity does not allow for the placement of axial implants.[9-11]

The All-on-4 implant concept (Nobel Biocare, Göteborg, Sweden) was developed to overcome anatomical limitations in the mandible that make it challenging to treat without the use of more complex techniques.[9] Based on the optimal number of four implants for supporting a full-

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arch prosthesis in an edentulous jaw, the concept benefits from the posterior tilting of the two distal implants with a maximum of a two-tooth distal cantilever in the final prosthesis.[9]

Besides the advantages described above, the use of tilted implants facilitates the achievement of the desired position of the implants from a prosthetic point of view[10] and creates a favorable interimplant distance.[11] Moreover, using finite element analysis, one can conclude that there is a biomechanical advantage in using splinted tilted distal implants rather than axial implants supporting distal cantilever units when comparing the coronal stress.[12] The protocol described in this article is an easy-to-use technique involving the use of a simple guide for optimal positioning and inclination of the implants, providing for superior loading conditions.

Findings of a previous study by members of our research team,[9] which involved a follow-up of up to three years, demonstrated that the complete prosthetic rehabilitation of the edentulous mandible by means of the All-on-4 concept is possible with good outcomes in the short and medium terms. The purpose of this article is to present the clinical outcome of the All-on-4 concept with a follow-up of up to 10 years. The research hypothesis we investigated in this study was the rehabilitation of completely edentulous mandibles via the All-on-4 concept.

## METHODS

We wrote this article according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines.[13] This longitudinal study was performed in the Malo Clinic Lisbon, a private clinic in Portugal, and was approved by an independent ethical committee.

From May 1999 to November 2004, 245 patients (96 men and 149 women; mean age, 59 years; age range, 23 to 85 years) underwent mandibular rehabilitation with immediately loaded full-arch prostheses supported by four implants, all placed anterior to the mental foramina—in total, 980 implants. The inclusion criterion was edentulous mandibles, or mandibles with hopeless teeth, in need of fixed implant restorations as requested by the patient. We included patients consecutively if they accepted the treatment and provided written informed consent. We excluded from the study any patients who had implants that had been placed in periodontally compromised areas (an extraction socket of a periodontally compromised tooth), patients who had implants placed in extraction sockets in which more than two-thirds of the implant had been inserted in the extraction socket, and patients who had bony dehiscences or fenestrations at the time of surgery.

As for the opposing dentition, 100 patients had an implant-supported fixed prosthesis, 31 patients had natural teeth, 21 patients had fixed prosthetics over natural teeth, 30 patients had a combination of natural teeth and implant-supported fixed prosthetics, and 63 patients had removable prostheses.

The types of implants inserted were distributed as follows: Brånemark System Mk II implants (Nobel Biocare) (n = 42), Brånemark System Mk III implants (Nobel Biocare) (n = 530), B Brånemark System Mk IV implants (Nobel Biocare) (n = 358) and Brånemark System NobelSpeedy implants (Nobel Biocare) (n = 50).

**Surgical protocol.** The patients provided a medical history and underwent clinical observation and complementary radiographic examinations with an orthopantomographic scan (for bone height evaluation) and a computerized tomographic scan (for evaluation of bone volume and anatomical structures such as the dental nerve).

Two of the authors (P.M. and A.L.) performed the surgical procedures after administering local anesthetic to the patients in the form of articaine hydrochloride (72 milligrams per 1.8 milliliters with epinephrine (0.018 mg/1.8 mL) 1:100,000. The clinicians sedated all patients with diazepam (Valium 10 mg, Roche, Amadora, Portugal) before performing surgery. Patients received the following drug therapy:

- antibiotics (amoxicillin, 875 mg, and clavulanic acid, 125 mg) one hour before surgery and daily for six days thereafter;
- cortisone medication (prednisolone, 5 mg) daily in a regression mode (15 to 5 mg) from the day of surgery until four days after surgery;
- anti-inflammatory medication (ibuprofen, 600 mg) for four days postoperatively starting on day four;
- analgesics (clonixine, 300 mg) on the day of surgery and postoperatively for the first three days if needed;
- antacid medication (omeprazole, 20 mg) on the day of surgery and daily for six days postoperatively.

The clinicians (P.M. and A.L.) inserted the implants according to standard procedures, except that they used underpreparation when needed to achieve a final torque of more than 32 newtons per centimeter before the final seating

**ABBREVIATION KEY. A:** Axial implant. **CSR:** Cumulative success rate. **T:** Tilted implant.