Journal of Cranio-Maxillofacial Surgery (2008) **36**, 403–409

doi:10.1016/j.jcms.2007.11.007, available online at http://www.sciencedirect.com

Total temporomandibular joint replacement: A clinical case with a proposal for post-surgical rehabilitation

Luca GUARDA-NARDINI, Daniele MANFREDINI, Giuseppe FERRONATO

TMD Clinic, Department of Maxillofacial Surgery, University of Padua, Italy

SUMMARY. Objective: **The literature on total alloplastic temporomandibular joint (TMJ) reconstructions is encouraging, and studies on total alloplastic TMJ replacements' outcomes showed acceptable improvements in terms of both pain levels and jaw function. Nevertheless, a better standardization of both surgical and post-surgical phases should further improve the efficacy of treatment.** Materials and methods: **The case report describes the surgical and post-surgical phases of treatment in a patient who underwent a total unilateral joint replacement for TMJ ankylosis, along with a proposal for a post-surgical rehabilitation protocol providing strong passive and active physiotherapy and hyaluronic acid injections to the contralateral joint.** Results: **The post-operative (PO) course was uneventful. The patient showed a marked improvement up to about 60% in mouth opening and had no pain on either side at the 1-year follow-up.** Conclusion: **In a patient with unilateral TMJ ankylosis, total TMJ replacement was successful. A carefully tailored post-surgical rehabilitation protocol helped the patient to gain a clinically significant improvement in jaw function. Longer follow-up periods are needed to assess the long-term maintenance of results. Clinical trials are strongly recommended to assess the relative efficacy of different PO protocols. © 2008 European Association for Cranio-Maxillofacial Surgery**

Keywords: **temporomandibular joint, temporomandibular joint prosthesis, temporomandibular joint ankylosis, physiotherapy, hyaluronic acid**

INTRODUCTION

The disorders of the temporomandibular joint (TMJ) are included in a heterogeneous group of pathologies termed temporomandibular disorders (TMDs), which may manifest with a constellation of signs and symptoms (*McNeill*, 1997). TMDs are considered the most frequent cause of chronic orofacial pain (*Rollman* and *Gillespie*, 2000) but, despite the introduction of the Research Diagnostic Criteria (RDC) for TMDs (*Dworkin* and *Leresche*, 1992) has improved standardization of the assessment and classification procedures in the research setting (*List* and *Dworkin*, 1996; *Rantala* et al., 2003; *Yap* et al., 2003; *Manfredini* et al., 2004a, 2006), poor diagnostic homogeneity exists among epidemiological investigations on TMD. Symptoms occur mainly in the 20–40 years of age-range, with a strong female representation (female:male ratio is about 3:1). The estimated prevalence of TMD-related orofacial pain of about 12% and the prevalence of TMD signs is up to 60% (*Dworkin* et al., 1990; *Leresche*, 1997). TMD-related pain has a relevant psychosocial impact as well (*Turner* et al., 2001; *Yap* et al., 2002; *Ferrando* et al., 2004; *Manfredini* et al., 2004b,c).

TMD symptomatic management is mainly based upon a number of conservative and reversible treatments, such as occlusal splints (*Dao* and *Lavigne*, 1998; *Turp* et al., 2004), physiotherapy (*Nicolakis* et al., 2002), complimentary medicine (*De Laat* et al., 2003), cognitive-behavioural interventions (*Dworkin* et al., 1994), and local or systemic drugs (*Dionne*, 1997; *Guarda Nardini* et al., 2002, 2005, 2007; *Manfredini* et al., 2004d). Nevertheless, a small number of cases is resistant to traditional conservative therapies and may request a surgical approach to the TMJ (*Nitzan* and *Dolwick*, 1990, 2003; *Valentini* et al., 2002; *Guven*, 2004; *Dimitroulis*, 2005; *Qudah* et al., 2005; *Erol* et al., 2006). Recently, the number of treatment options for the management of patients who had previously experienced multiple failed TMJ therapies has been enlarged with the introduction of the TMJ prosthesis (*Mercuri*, 1998, 1999a).

Studies on total alloplastic TMJ replacement outcomes showed acceptable improvements in terms of both pain levels and jaw function, thus making these interventions worthy of further evaluation (*Mercuri* et al., 2002; *Speculand* et al., 2002; *Mercuri* and *Giobbie-Hurder*, 2004). Nevertheless, the indications for TMJ prostheses and their success and survival rates have yet to be defined (*Guarda Nardini* et al., 2008).

Considering the increasing interest in TMJ prosthetic replacement, it appears that both surgical and post-surgical phases of treatment need to be standardized. In particular, the existing literature shows that little attention has been paid to the post-intervention rehabilitation.

To address these concerns, the present case report describes the surgical and post-surgical phases in a patient who underwent a total unilateral TMJ replacement, along with a proposal for a post-surgical rehabilitation protocol.

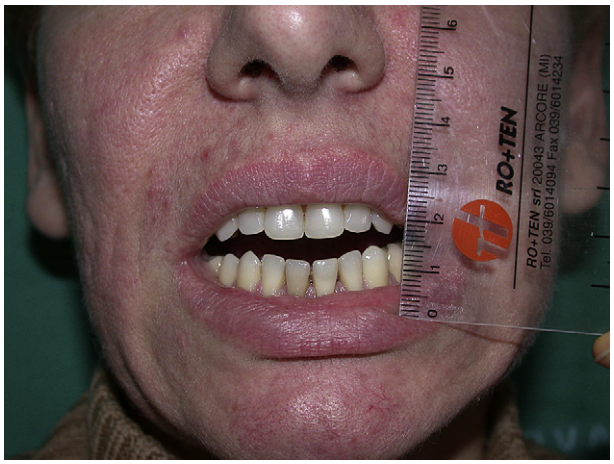

Fig. 1 – Baseline time. Range of mouth opening.

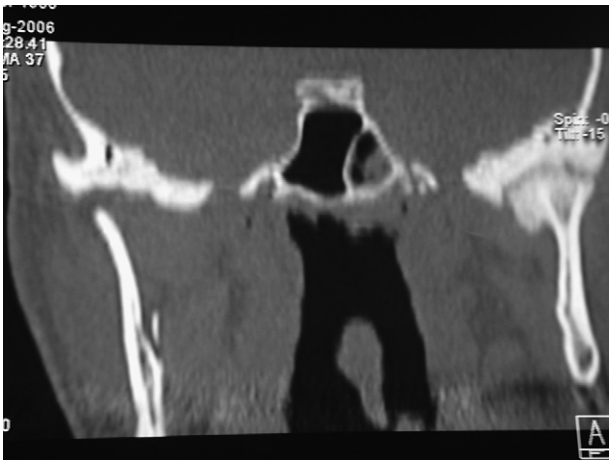

Fig. 2 – Computerized tomography showing ankylosis of the left TMJ.

CASE DESCRIPTION

A 35-year-old female patient (R.L.) was referred to the Department of Maxillofacial Surgery, University of Padua, Italy, for the treatment of a severe mouth opening restriction and pain in the TMJ (Fig. 1).

The patient gave a history of pain in the TMJ area and had undergone two previous operations.

At 25 years, she underwent surgery for temporomandibular disc repositioning due to persistent pain in the left joint associated with disc displacement. Symptoms and joint sounds resolved after the intervention, but 7 years later she started pain and functional limitation again.

At 32 years, she underwent a second surgery for left TMJ discectomy with condylar remodelling.

Post-operatively, the range of mandibular movements decreased rapidly, and the patient was referred to the TMD clinic, Department of Maxillofacial Surgery of the University of Padua, Italy. The maximum mouth opening was 5 mm, with absence of endfeel distance, and computerized tomography showed ankylosis of the left TMJ (Figs. 2 and 3). A RDC for TMD (*Dworkin* and *Leresche*, 1992) axis I diagnosis of disc displacement with reduction (group IIa) and osteoarthritis (group IIIb) was made for the right joint.

Several surgical options should exist to relieve TMJ ankylosis and try to restore function, ranging from the quite abandoned gap arthroplasty to interpositional arthroplasty, which provided the insertion of a biological (temporalis fascia, temporal muscle flap) or non-biological material (acrylic, silastic) between the bone structures (*Su-Gwan*, 2001; *Valentini* et al., 2002; *Manganello-Souza* and *Mariani*, 2003; *Guven*, 2004; *Qudah* et al., 2005; *Erol* et al., 2006; *Manfredini* et al., in press). Nevertheless, in the case of patients undergoing multiple previous operations, there is a high risk of reankylosis, and a TMJ replacement should be considered (*Mercuri*, 1998, 1999a). The literature suggests that a total TMJ replacement system is preferable to a partial replacement to avoid excessive stress and wear of the articular bone surface working against the prosthesis, which can prevent

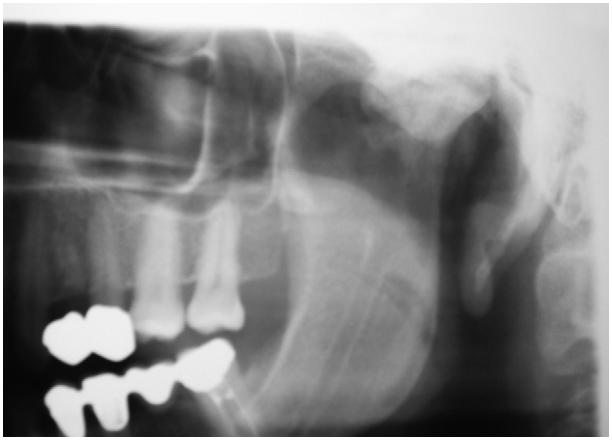

Fig. 3 – Ortopantomography showing ankylosis of the left TMJ.

long-term functional restoration (*Mercuri*, 1999a; *Quinn*, 2000).

Considering these concerns, a total TMJ prosthesis in the left joint was preferred to the other surgical options, and the patient was scheduled for surgery.

The total TMJ replacement system is a "ball and socket" type prosthetic joint similar to a hip implant. The total TMJ replacement system comprises three components (*Guarda Nardini* et al., 2008):

- The condylar (or mandibular) implant, made of metal cobalt–chromium–molybdenum (Co–Cr–Mo) alloy or titanium alloy. In both cases the implants have a roughened titanium porous coating on the implant surface that contacts bone. Co–Cr–Mo alloy contains nickel.
- The fossa implant, made of a hard, plastic polyethylene. The fossa is made of high density polyethylene that has shown excellent wear resistance during mechanical testing.
- The screws, made of titanium alloy, are used to attach both the condylar and the fossa implants to bone.

In this case a total TMJ prosthesis was inserted (Biomet/Lorenz, Warsaw, IN, USA) (*Quinn*, 2000).

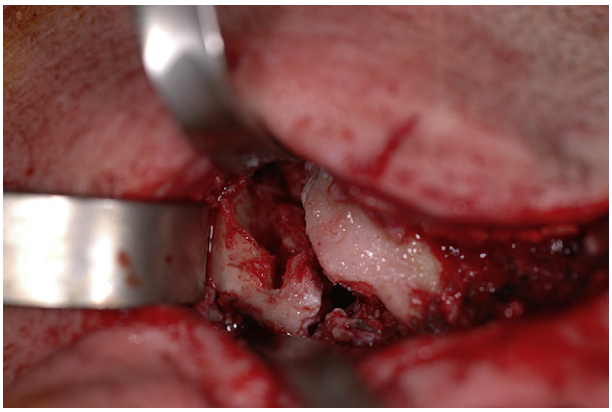

Fig. 4 – Removal of the ankylosis.

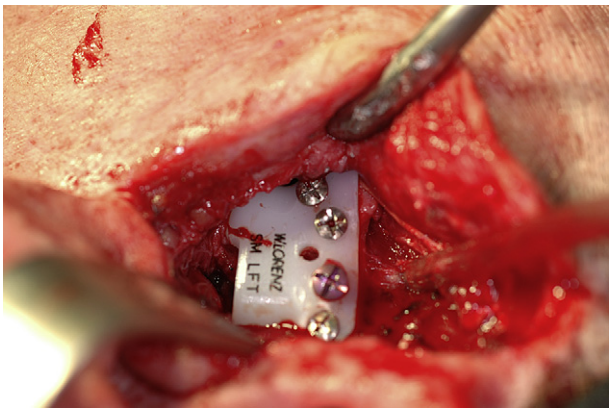

Fig. 5 – Fitting of the fossa component of the prosthesis.

The Biomet/Lorenz® prosthetic system is a stock prosthesis which is provided in three different sizes for both the condylar/mandibular and the fossa implants.

The fossa component is made up of ultra-high molecular weight polyethylene (UHMWPE), while the condylar/mandibular component is made up of a Co–Cr–Mo alloy with titanium surfaces.

The former is fixed to bone tissue by means of 4–7 screws of 2.0 mm diameter, while the latter is fixed by means of 7–11 screws of 2.7 mm diameter.

SURGICAL TECHNIQUE

The operation consists of two phases: the removal of the ankylosis and the positioning of the TMJ prosthesis. Thus, both preauricular access to the TMJ and temporal bone and a posteroinferior submandibular incision for access to the mandibular ramus were required (*Quinn*, 2000). The superior incision has a 45° release into the temporal hairline, and the dissection is kept as posterior as possible to avoid the facial nerve. The inferior incision was almost vertical (i.e., perpendicular to the lower two-thirds of the posterior border of the ramus) (*Quinn*, 2000).

Once access to the TMJ was gained through the preauricular incision, the release of the ankylosis was performed (Fig. 4). A 5–10 mm gap between the recountoured glenoid fossa and the mandible was created by removing the fibrous scar and heterotopic osseus tissue with surgical burs and chisels. Remodelling of the glenoid fossa and a partial excision of the coronoid process were performed to fit the fossa component of the prosthesis (Fig. 5).

Once the fossa component was placed and fixed, the patient was placed in the post-operatory intermaxillary relationship, which was secured with wire (Fig. 6). Condylectomy was then performed and the mandibular component of the prosthesis was placed and fixed (Fig. 7).

The intermaxillary fixation was then removed and the patient's mandible was manipulated to ensure that no obstructions to joint movement or improper fitting between the two prosthetic components were present. The patient was also forced intra-operatively to maximum mouth opening, in order to break adhesions on the contralateral side. Only after verifying the correct functioning and freedom of movement of the implant, the patient was then sutured and a control ortopantomography was taken (Figs. 8 and 9).

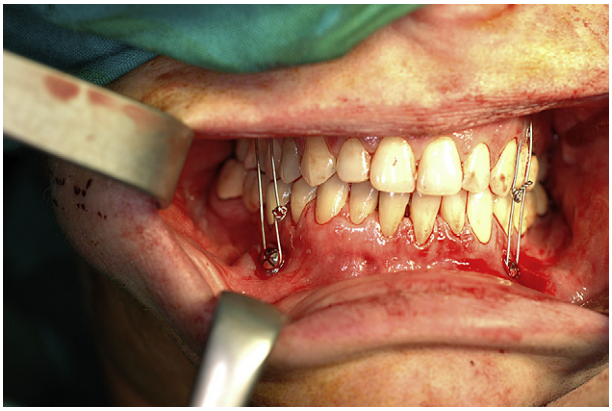

Fig. 6 – Wire fixation was intra-operatively performed to secure the post-operatory intermaxillary relationship.

POST-OPERATORY PROTOCOL

While there is growing documentation and interest in the surgical aspects of the TMJ prosthetic rehabilitation, there is a paucity of data about the post-operative (PO) protocols. This appears to be an oversight, since the choice of appropriate PO rehabilitation has a strong influence on therapeutic outcomes. An accurate description of the post-operatory rehabilitative program adopted allows a more appropriate comparison of the study findings, and its definition and standardization is of importance clinically.

In this case, the PO course was uneventful, and only PO pain medication and antibiotics were prescribed. There was no motor deficit on either side of the face.

The day after surgery, post-operatory mouth opening was 23 mm (Fig. 10).

Functional rehabilitation was started 1 week after surgery, by a combination of active and passive exercises. In particular, the patient was given an intensive regime of passive motion (TheraBite Jaw Motion Rehabilitation

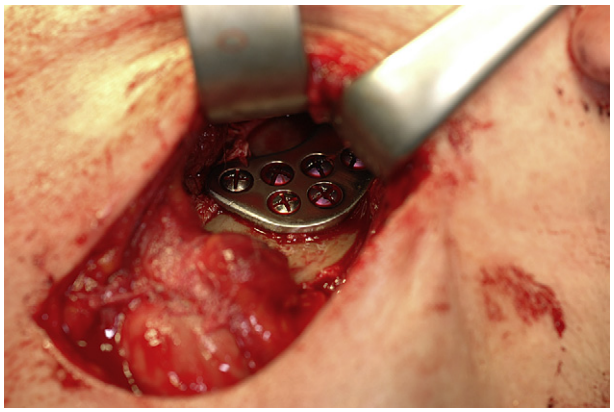

Fig. 7 – Fitting of the mandibular/condylar component of the prosthesis.

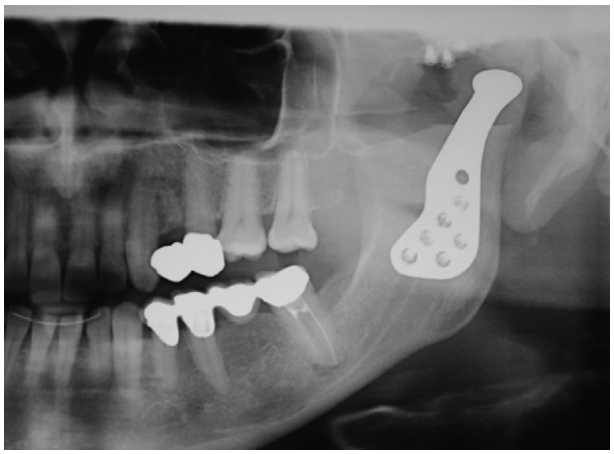

Fig. 8 – Ortopantomography performed immediately after surgery.

System®, Therabite, Philadelphia, PA, USA), which, according to some data, is important in improving jaw mobility after surgical procedures on the TMJ (*Mercuri* et al., 2002; *Cohen* et al., 2005; *Gibbons* and *Abulhoul*, 2006). The treatment regime was based on the protocol suggested by Therabite for cases of limited jaw mobility, and provided that the patient opens the mouth with assistance seven times, holds the maximum open position that can be sustained for 7 s, and performs these exercises seven times a day. The patient was asked to perform passive exercises for the first 3 months after surgery, and vigorous active physiotherapy was then introduced to maintain the mobility.

A cycle of hyaluronic acid injections was also provided to the contralateral TMJ, in order to improve function (Fig. 11). The protocol for joint injections was moderated from those adopted in larger joints, providing a cycle of five injections (one per week) of 1 ml low-molecular weight hyaluronic acid (Hyalgan®, Fidia, Abano Terme, Italy), performed according to the technique described elsewhere (*Guarda Nardini* et al., 2002, 2005, 2007).

Five follow-up assessments were performed (at 1 week, at 1, 3, 6, and 12 months). Mouth opening after 1 year was 41 mm and the patient said both sides were pain free (Fig. 12).

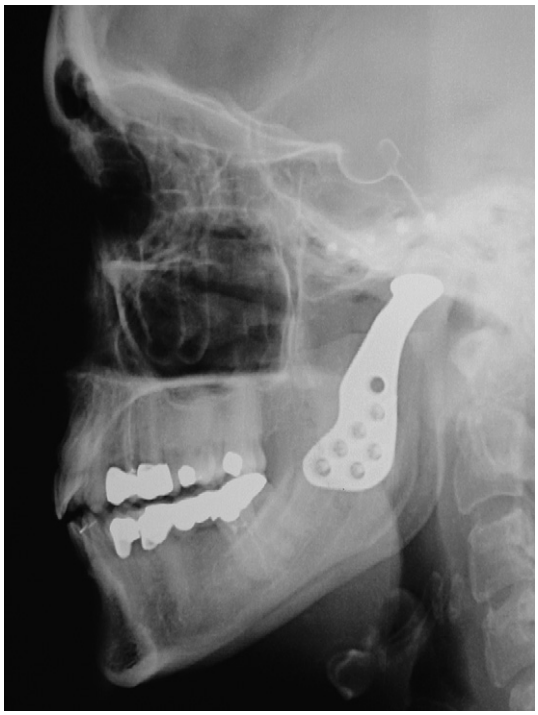

Fig. 9 – Latero-lateral X-rays performed immediately after surgery.

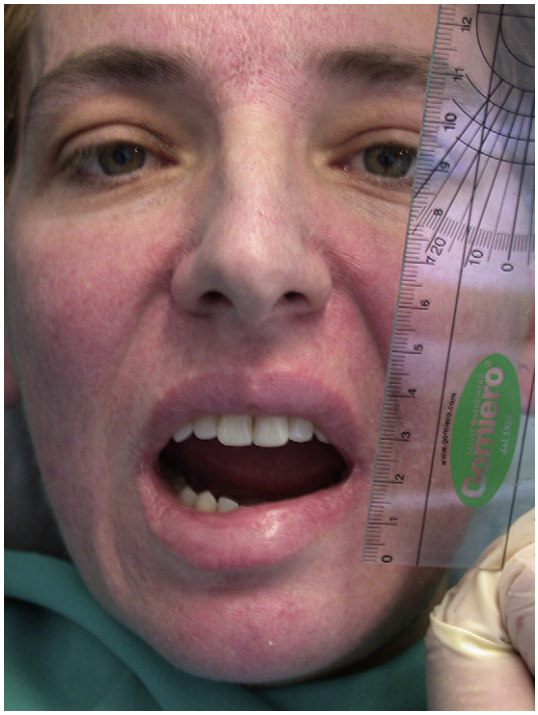

Fig. 10 – Post-surgical mouth opening.

DISCUSSION

Data on total TMJ replacements suggest that a history of multiple previous failed operations is the most common indication for joint replacement, and patients with severe osteoarthritis, inflammatory arthrosis, connective or

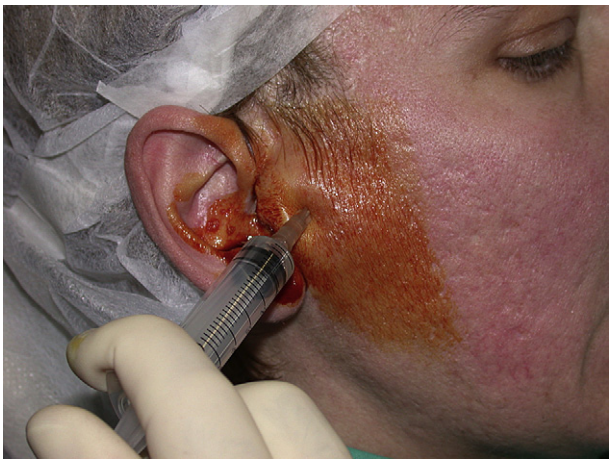

Fig. 11 – Hyaluronic acid injections in the contralateral side.

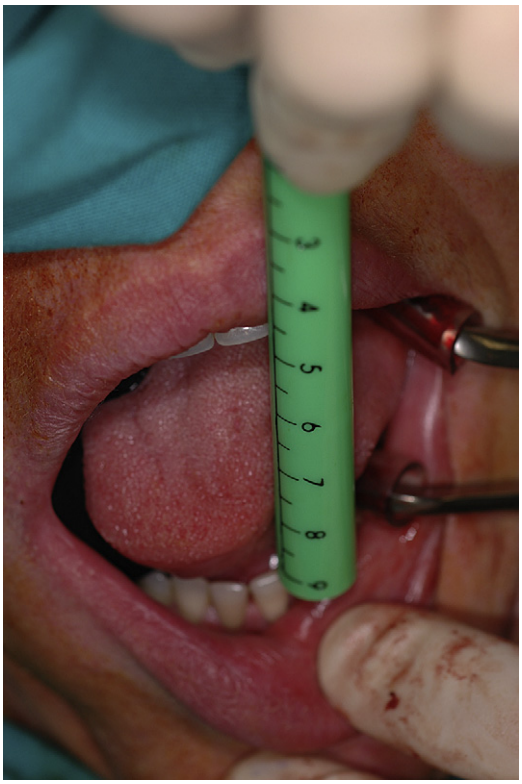

Fig. 12 – Mouth opening at the 1-year follow-up.

autoimmune disease, ankylosis, absent or deformed structures, congenital deformities, and chronic pain also underwent the total joint replacement (*Mercuri*, 1999a,b; *Quinn*, 2000; *Saeed* et al., 2002; *Wolford* et al., 2003; *Christensen* et al., 2005).

In general, total alloplastic TMJ replacements interventions have shown promising outcomes, and reported improvements are good for both subjective (pain levels) and objective (jaw function) clinical parameters, even though a generalization of results is limited by the low number of available studies, which involved few surgeons and manufacturers (*Guarda Nardini* et al., 2008).

Studies on total TMJ prosthetic systems have a follow-up period ranging from 1 to 5 years, and all of them reported significant improvement in both objective (range of movements) and subjective (pain, mandibular function, diet consistency, quality of life) clinical parameters, in both uni- and bilateral replacements. Mean pain reduction was within the 50–67% range, and increase in mouth opening was about 30% (*Mercuri*, 1999b; *Mercuri* et al., 2002; *Saeed* et al., 2002; *Speculand* et al., 2002; *Wolford* et al., 2003; *Mercuri* and *Giobbie-Hurder*, 2004; *Christensen* et al., 2005).

Nevertheless, the existing literature shows that little attention has been paid to the description of post-intervention rehabilitation, and findings might have been even more encouraging if the importance of post-surgical phases had been accurately emphasized.

Functional rehabilitation has a strong and well-documented importance in many fields of orthopaedics (*NIH Panel*, 2003) and passive jaw rehabilitation devices have been shown to have some value in PO TMJ rehabilitation (*Mercuri* et al., 2002; *Cohen* et al., 2005; *Gibbons* and *Abulhoul*, 2006).

In the case described, passive physiotherapy was performed for 3 months after surgery, and then active rehabilitation was introduced. The TheraBite system was adopted to perform passive jaw motion due to its effectiveness in terms of cost–benefit ratio and to its simplicity. Also, the adoption of an easy-to-use non-individualized system might help to improve standardization of PO protocols, thus making a comparative cross-study possible.

In order to improve jaw mobility and to avoid possible limitations in the range of movements due to the contralateral non-operated TMJ, a cycle of hyaluronic injections was also performed on the right joint. Hyaluronic acid, being an essential component for joints lubrication, may help to reduce joint friction (*Cascone* et al., 2002; *Tanaka* et al., 2005), and literature data are currently available on the efficacy of intra-articular hyaluronic acid injections in patients with disc displacement with reduction (*Hepguler* et al., 2002), disc displacement without reduction (*Sato* et al., 1997; *Sato* et al., 2001), and with osteoarthritis (*Guarda Nardini* et al., 2002, 2005, 2007).

Improvements in mouth opening at the 1-year follow-up were up to 60%, being more marked than those reported in the literature (*Mercuri*, 1999b; *Mercuri* et al., 2002; *Saeed* et al., 2002; *Speculand* et al., 2002; *Wolford* et al., 2003; *Mercuri* and *Giobbie-Hurder*, 2004; *Christensen* et al., 2005), and one can suppose that the adopted post-operatory protocol was an important component to explain this finding.

CONCLUSIONS

The present report describes a successful case of an intervention for a unilateral total TMJ replacement in a patient with TMJ ankylosis. The PO course was uneventful, and a carefully tailored post-surgical rehabilitation protocol helped the patient to achieve a clinically significant improvement in jaw function.

It appears obvious that a single clinical case report has small scientific significance, and that longer follow-up

periods are needed to assess the long-term maintenance of results.

Nevertheless, it must be pointed out that a description of the post-operatory protocols and an evaluation of the relative effectiveness of different regimens have not addressed aspects of TMJ total replacement to date, so that further studies are essential to improve knowledge about the management of post-surgical phases.

References

Cascone P, Fonzi Dagger L, Aboh IV: Hyaluronic acid's biomechanical stabilization function in the temporomandibular joint. J Craniofac Surg 13: 751−754, 2002

Christensen RW, Walker CR, Dollar JV: New hope for Treacher-Collins syndrome: a surgical case report. Surg Technol Int 14: 319−327, 2005

Cohen EG, Deschler DG, Walsh K, Hayden RE: Early use of a mechanical stretching device to improve mandibular mobility after composite resection: a pilot study. Arch Phys Med Rehabil 86: 1416−1419, 2005

Dao TT, Lavigne GJ: Oral splints: the crutches for temporomandibular disorders and bruxism? Crit Rev Oral Biol Med 9: 345−361, 1998

De Laat A, Stappaers K, Papy S: Counseling and physical therapy as treatment for myofascial pain of the masticatory system. J Orofac Pain 17: 42−49, 2003

Dimitroulis G: The role of surgery in the management of disorders of the temporomandibular joint: a critical review of the literature. Part 1. Int J Oral Maxillofac Surg 34: 107−113, 2005

Dionne RA: Pharmacologic treatments for temporomandibular disorders. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 83: 134−142, 1997

Dworkin SF, Huggins KH, Leresche L, Von Korff M, Howard J, Truelove EL, Sommers E: Epidemiology of signs and symptoms in tempromandibular disorders: clinical signs in case and controls. J Am Dent Assoc 120: 273−281, 1990

Dworkin SF, Leresche L: Research diagnostic criteria for temporomandibular disorders: review, criteria, examinations and specifications, critique. J Craniomandib Disord 6: 301−355, 1992

Dworkin SF, Turner JA, Wilson L, Massoth D, Whitney C, Huggins KH, Burgess J, Sommers E, Truelove E: Brief group cognitive-behavioral intervention for temporomandibular disorders. Pain 59: 175−187, 1994

Erol B, Tanrikulu R, Gorgun B: A clinical study on ankylosis of the temporomandibular joint. J Craniomaxillofac Surg 34: 100−106, 2006

Ferrando M, Andreu Y, Galdon MJ, Durà E, Poveda R, Bagan JV: Psychological variables and temporomandibular disorders: distress, coping and personality. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 98: 153−160, 2004

Gibbons AJ, Abulhoul S: Use of a Therabite appliance in the management of bilateral mandibular coronoid hyperplasia. Br J Oral Maxillofac Surg 12, 2006 [E-pub ahead of print]

Guarda Nardini L, Tito R, Staffieri A, Beltrame A: Treatment of patients with arthrosis of the temporomandibular joint by infiltration of hyaluronic acid: a preliminary study. Eur Arch Otorhinolaryngol 259: 279−284, 2002

Guarda Nardini L, Masiero S, Marioni G: Conservative treatment of temporomandibular joint osteoarthrosis: intra-articular injection of hyaluronic acid. J Oral Rehabil 32: 729−734, 2005

Guarda Nardini L, Stifano M, Brombin C, Salmaso L, Manfredini D: A one year case series of arthrocentesis with hyaluronic acid injections for temporomandibular joint osteoarthritis. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 103: e14−e22, 2007

Guarda Nardini L, Manfredini D, Ferronato G: Temporomandibular joint total replacement prosthesis: current knowledge and considerations for the future. Int J Oral Maxillofac Surg 37: 103−110, 2008

Guven O: Treatment of temporomandibular joint ankylosis by a modified fossa prosthesis. J Craniomaxillofac Surg 32: 236−242, 2004

Hepguler S, Akkoc YS, Pehlivan M, Ozturk C, Celebi G, Saracoglu A, Opzinar B: The efficacy of intra-articular hyaluronic acid in patients with reducing displaced disc of the temporomandibular joint. J Oral Rehabil 29: 80−86, 2002

Leresche L: Epidemiology of temporomandibular disorders: implications for the investigation of etiologic factors. Crit Rev Oral Biol Med 8: 291−305, 1997

List T, Dworkin SF: Comparing TMD diagnoses and clinical findings at Swedish and US TMD center using Research Diagnostic Criteria for Temporomandibular Disorders. J Orofac Pain 10: 240−253, 1996

Manfredini D, Segù M, Bertacci A, Binotti G, Bosco M: Diagnosis of temporomandibular disorders according to RDC/TMD axis I findings. Minerva Stomatol 53: 429−438, 2004a

Manfredini D, Bandettini Di Poggio A, Cantini E, Dell'Osso L: Mood and anxiety psychopatology and temporomandibular disorder: a spectrum approach. J Oral Rehabil 31: 933−940, 2004b

Manfredini D, Bandettini di Poggio A, Romagnoli M, Dell'Osso L, Bosco M: Mood spectrum in patients with different painful temporomandibular disorders. Cranio 22: 234−240, 2004c

Manfredini D, Romagnoli M, Cantini E, Bosco M: Efficacy of tizanidine hydrochloride in the treatment of myofascial face pain. Minerva Med 95: 165−171, 2004d

Manfredini D, Chiappe G, Bosco M: Research Diagnostic Criteria for Temporomandibular Disorders (RDC/TMD) axis I diagnosis in an italian patients population. J Oral Rehabil 33: 551−558, 2006

Manfredini D, Bucci MB, Guarda Nardini L, Ferronato G: Temporomandibular joint bilateral post-traumatic ankylosis: a report of a case treated with interpositional arthroplasty. Minerva Stomatol, in press.

Manganello-Souza LC, Mariani PB: Temporomandibular joint ankylosis: report of 14 cases. Int J Oral Maxillofac Surg 32: 24−29, 2003

McNeill C: Management of temporomandibular disorders: concepts and controversies. J Prosthet Dent 77: 510−522, 1997

Mercuri LG: Alloplastic temporomandibular joint reconstruction. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 85: 631−637, 1998

Mercuri LG: Considering total temporomandibular joint replacement. Cranio 17: 44−48, 1999a

Mercuri LG: Subjective and objective outcomes in patients reconstructed with a custom-fitted alloplastic temporomandibular joint prosthesis. J Oral Maxillofac Surg 57: 1427−1430, 1999b

Mercuri LG, Sanders B, Giobbie-Hurder A: Long-term follow-up of the CAD/CAM patient fitted total temporomandibular joint reconstruction system. J Oral Maxillofac Surg 60: 1440−1448, 2002

Mercuri LG, Giobbie-Hurder A: Long-term outcomes after total alloplastic temporomandibular joint reconstruction following exposure to failed materials. J Oral Maxillofac Surg 62: 1088−1096, 2004

Nicolakis P, Erdogmus CB, Kopf A, Nicolakis M, Piehslinger E, Fiala-Moser V: Effectiveness of exercise therapy in patients with myofascial pain dysfunction sindrome. J Oral Rehabil 29: 362−368, 2002

NIH Panel: National Insitute of Health Consensus Statement on total knee replacement. NIH Consen State Sci Statements 20: 1−34, 2003

Nitzan DW, Dolwick MF: Arthroscopic lavage and lysis of the TMJ: a change in perspective. J Oral Maxillofac Surg 48: 798−801, 1990

Nitzan DW, Dolwick MF: Rationale and indications for arthrocentesis of the TMJ. Alpha Omegan 96: 57−63, 2003

Qudah MA, Qudemait MA, Al-Maaita J: Treatment of TMJ ankylosis in Jordanian children − a comparison of two surgical techniques. J Craniomaxillofac Surg 33: 30−36, 2005

Quinn PD: Lorenz prosthesis. Oral Maxillofac Surg Clin North Am 12: 93−104, 2000

Rantala MAI, Ahlberg J, Savolainen A, Könönen M: Symptoms, signs, and clinical diagnoses according to Research Diagnostic Criteria for Temporomandibular Disorders among Finnish Multiprofessional Media Personnel. J Orofac Pain 17: 21−28, 2003

Rollman GB, Gillespie JM: The role of psychosocial factors in temporomandibular disorders. Curr Rev Pain 4: 71−81, 2000

Saeed N, Hensher R, McLeod N, Kent J: Reconstruction of the temporomandibular joint autogenous compared with alloplastic. Br J Oral Maxillofac Surg 40: 296−299, 2002

Sato S, Ohta M, Ohki H, Kawamura H, Motegi K: Effect of lavage with injection of hyaluronic acid for patients with nonreducing disk displacement of the temporomandibular joint. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 84: 241−244, 1997

Sato S, Oguri S, Yamaguchi K, Kawamura H, Motegi K: Pumping injection of hyaluronic acid for patients with non-reducing disc

displacement of the temporomandibular joint: two year follow-up. J Craniomaxillofac Surg 29: 89−93, 2001
Speculand B, Hensher R, Powell D: Total prosthetic replacement of the TMJ: experience with two systems 1988−1997. Br J Oral Maxillofac Surg 38: 360−369, 2002
Su-Gwan K: Treatment of temporomandibular joint ankylosis with temporalis muscle and fascia flap. Int J Oral Maxillofac Surg 30: 189−193, 2001
Tanaka E, Iwabe T, Dalla-Bona DA, Kawai N, van Eijden J, Tanaka M, Kitagawa S, Takata T, Tanne K: The effect of experimental cartilage damage and impairment and restoration of synovial lubrication on friction in the temporomandibular joint. J Orofac Pain 19: 331−336, 2005
Turner J, Dworkin S, Mancl L, Huggins K, Truelove E: The roles of beliefs, catastrophizing and coping in the functioning of patients with temporomandibular disorders. Pain 92: 41−51, 2001
Turp JC, Komine F, Hugger A: Efficacy of stabilization splints for the management of patients with masticatory muscle pain: a qualitative systematic review. Clin Oral Investig 8: 179−195, 2004
Valentini V, Vetrano S, Agrillo A, Torrino A, Fabiani F, Iannetti G: Surgical treatment of TMJ ankylosis: our experience (60 cases). J Craniofac Surg 13: 59−67, 2002
Wolford LM, Pitta MC, Reiche-Fischel O, Franco PF: TMJ concepts/techmedica custom-made TMJ total joint prosthesis: 5-year follow-up study. Int J Oral Maxillofac Surg 32: 268−274, 2003
Yap AUJ, Chua E, Hoe KE: Clinical TMD, pain related dysability and psychological status of TMD patients. J Oral Rehabil 29: 374−380, 2002
Yap AJU, Dworkin SF, Chua EK, List T, Tan KBC, Tan HH: Prevalence of temporomandibular disorders subtypes, psychologic distress and psychosocial dysfunction in Asian patients. J Orofac Pain 17: 21−28, 2003

Dr. Daniele MANFREDINI
V.le XX Settembre 298
54036 Marina di Carrara (MS), Italy

Tel.: +39 0585 630964
Fax: +39 0585 792485
E-mail: daniele.manfredini@tin.it

Paper received 16 July 2007
Accepted 2 November 2007