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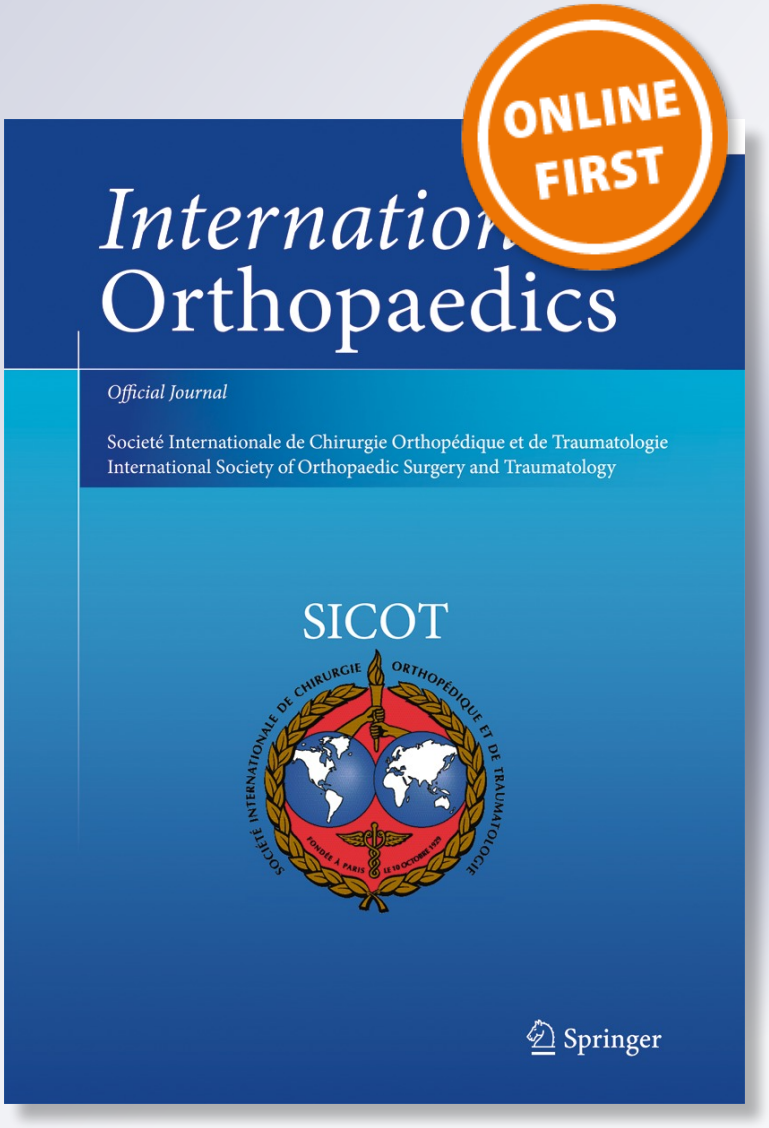

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ORIGINAL ARTICLE

A convertible shoulder system: is it useful in total shoulder arthroplasty revisions?

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Abstract
Purpose The frequency of total shoulder arthroplasty (TSA) implantation is constantly increasing. This leads to revisions because of stem or glenoid component loosening, infection, instability or glenoid subsidence. Significant rotator cuff lesions and/or bone loss necessitate reverse shoulder arthroplasty (RSA) with bone reconstruction, which is a demanding procedure.

Our hypothesis is that a platform system (versatile humeral stem with metal back glenoid component) makes revision surgery less demanding and less time consuming, and helps reduce the risks of complication. The purpose of this study is to analyse our revision experience with such a system to support our hypothesis.
Methods We present 29 revision cases of a convertible platform shoulder system: five hemi arthroplasties (HA), eight TSA with cemented glenoid (TSACG) and 16 TSA with metal backed glenoid component (TSAMB).

Three TSACG were switched to TSAMB, and 26 other arthroplasties were switched to RSA. The pre-operative Constant score was 27 (range, 0–38). Our revision incidence was 5.4 % (29 revisions out of 537 shoulder arthroplasties over five years).
Results At revision, Constant score was 60 (range, 42–85). The humeral stem (versatile with TSA and RSA) was kept in three out of four cases. Most of the time it was changed because of too high a position, making it impossible to reduce the RSA. Nevertheless, 12 PTAMB were switched in 12 RSA without any metal backed revisions.
Conclusion A platform shoulder system allows much easier revisions.

Keywords Total shoulder arthroplasty · Revision · Platform shoulder system · Convertible system

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Introduction

The annual number of shoulder replacement is far lower than any other joint replacement, i.e. about 8 % of total hip replacements in France according to ATIH (Agence Technique de l'Information sur l'Hospitalisation). Nevertheless, good shoulder arthroplasty results lead to an increase in the number of implantations. From 2006 to 2010 there was a relative increase of shoulder prosthesis implantations (13 %) and more than 15 % since 2012 to now. As a result, an increasing number of implantations leads to repeat surgery for any cause whatsoever. In France this is substantiated by the 29 % increase in the number of reverse shoulder arthroplasty between 2006 and 2010 (ATIH).

The survival rate is 80 % after 15 years [1, 2]. Nevertheless, 10–16 % of complications have been described before the fifth year of follow-up [3, 4], and 20 % of the patients will need revision before the 15th year of follow-up. Among the varied causes of revision there are glenoid loosening, instability, failure after hemi arthroplasty in trauma, secondary RCT and infections [5, 6].

While the glenoid is being revised, bone loss and massive rotator cuff tear are quite common. In such circumstances it is

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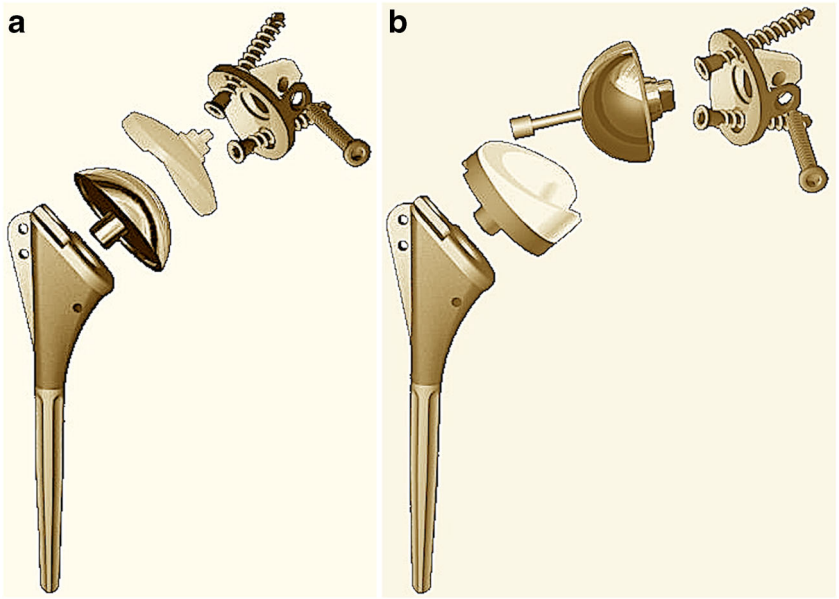

Fig. 1 A shoulder platform convertible system allows switching from a total anatomic shoulder arthroplasty to a reverse one, without any stem and/or glenoid component revision

recommended to implant a reverse shoulder arthroplasty (RSA) with glenoid bone reconstruction [7, 8]. As a result stem revision is also needed since the systems are not convertible. Humeral shaft corticotomy (sarcophagus) is necessary as stem loosening is rare, with a 20–25 % incidence of fracture [9, 10].

A platform system allows switching an anatomical arthroplasty to a reverse one without any revisions of the stem and/or glenoid component (Fig. 1a and b).

In 2003 we hypothesized that with the help of a platform system, revision surgeries could be less demanding and less time consuming with fewer complications and therefore would promote quicker healing.

The purpose of this study was to analyse the advantages and drawbacks of this platform system in TSA revisions.

Materials and methods

Patient selection

We present a retrospective series of 29 patients who underwent a revision surgery of a platform shoulder system over five years. The Arrow® convertible system (FH Orthopedics, Mulhouse, France) was used for every patient. Three experienced surgeons in three different hospitals operated on those cases. Out of the 537 shoulder prostheses performed between 2006 and 2011, 29 needed a revision surgery. The mean age was 67 years (σ=7.6); there were 22 women and seven men. The right side was operated on in 55.2 % and the dominant side was operated on in 14 cases. Only hemi arthroplasties (HA), total shoulder arthroplasties with cemented glenoid (TSACG) and total shoulder arthroplasties with metal-back (TSAMB) were included. Revisions of RSA were not within the scope of the study. Five HA were converted to a RSA, three TSACG had their polyethylene-glenoid component removed for a metal back glenoid component, five TSACG and the 16 TSAMB were converted to a RSA. The revision rate was 5.4 % over those five years. Aetiologies for undergoing a revision surgery are detailed in Table 1. Pain, glenoid loosening, pseudo-paralytic shoulder, postero-superior rotator cuff tear, subscapularis tear, dislocation, glenoiditis and tuberosity osteolysis were the main causes for revision. Combined aetiologies (as anterior shoulder dislocation combined with subscapularis tear) were frequent, which explains why we have more aetiologies than patients.

Surgical technique

All the patients were operated on under general anaesthesia with an interscalenic block either in beach-chair position or in supine position with a sandbag placed under the spine at the

Table 1 Revision's etiologies

Etiology	Number of incidences
Glenoid loosening	7
Pseudo-paralytic shoulder	2
Rotator cuff tear	10
Anterior shoulder dislocation	2
Posterior shoulder dislocation	3
Glenoiditis	4
Tuberosity osteolysis	1
Total	29

medial end of the scapula to allow the shoulder to rotate externally and to open the anterior part of the joint. We used a deltopectoral approach in every case to allow distal extension of the exposure in case of stem removing. The deltopectoral approach was made during the primary procedure as well. The long head of the biceps was previously cut and fixed onto the lesser tuberosity. In case of continuous and functional rotator cuff, the stem was left and the lost cemented glenoid was switched for a MB glenoid only. Conversely, in cases of thin, fibrotic or considered as non-functional rotator cuff tear, RSA was made. The Arrow convertible system is a platform system, whereby the humeral stem and the glenoid MB is common regardless the type of arthroplasty. Therefore the system allows shifting from TSA to RSA without any humeral stem and/or glenoid MB revision making surgery less demanding, less invasive and less time consuming (Figs. 2, 3, 4, 5, and 6). Nevertheless, the humeral stem and/or glenoid component had to be revised in cases of loosening or malposition (excessive retroversion/anteversion and/or level malposition). A bone graft was made with iliac crest bone in cases of glenoid bone loss. In every case a minimum of five cultures were made in order to diagnose unexpected positive microorganisms.

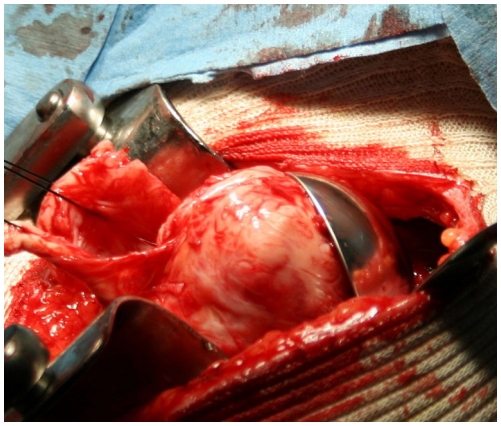

Fig. 3 Deltopectoral approach; no cuff

Patient assessment

We performed the Constant-Murley test for each patient preoperatively and at the last follow-up. The strength was measured with a electronic dynamometer; the surgeon performed the range of motion evaluation. The pain was assessed with the visual analogic scale (VAS) and the "simple shoulder test" was performed during the medical examination. We also made a radiological assessment of the prosthesis to detect a stem or glenoid loosening.

Statistic analysis

Data were analysed with SPSS® version 20.0 (SPSS IBM, New York, USA). The Shapiro-Wilk test was used to assess the normality of the variables' distribution. The Student *t*-test for paired groups was used when data were following a normal distribution. When the data distribution was not normal the Wilcoxon non-parametric test was used. The level of significance was set at 0.05 ($p<0.05$).

Results

The mean follow-up was 28 months ($\sigma=18$). We did not have any radiological glenoid or stem loosening at the last follow-up. The results of the statistical analysis of the function are reported in Table 2. We found four patients (one HA, one TSAGC, two TSAMB) with five positive cultures each. The

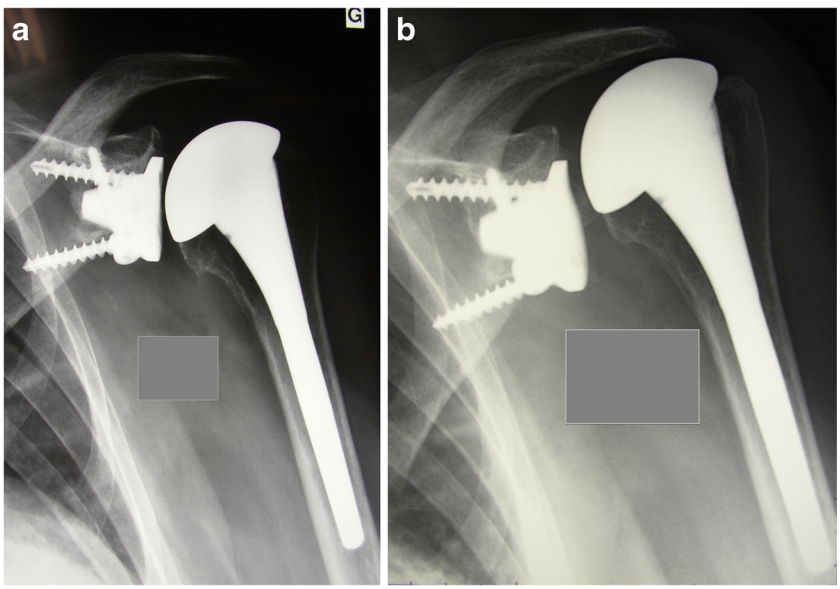

Fig. 2 **a** Plain X-ray of a TSA just after implantation. The humeral head is exactly in front of the glenoid as there is no rotator cuff tear. **b** Same patient with superior escape after two-year TSAMB implantation secondary to rotator cuff tear

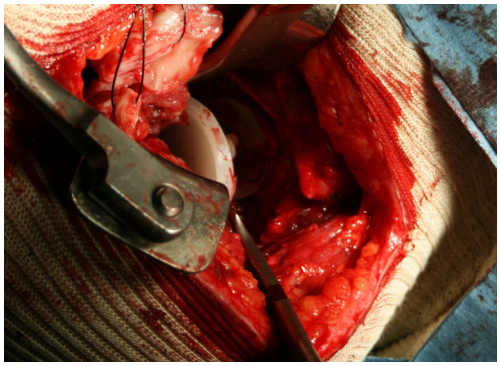

Fig. 4 No PE wear

microorganism was *Propioni bacterium acnes* for three cases and *Staphylococcus epidermidis* for one. We made a one-stage procedure with new component implantation (RSA), wild infected soft tissue excision and a three-month antibiotics prescription. Those four patients were excluded because it was not possible to keep implants for conversion. For the remaining 25 patients every aspect of the clinical assessments was significantly increased after the revision surgery. The humeral stem was kept in 18 cases (72 %). The main reason for the stem change was its high position making the RSA reduction impossible to perform in seven cases (24 %). We did not need any humeral shaft corticotomy and/or distal window. Two metal back glenoid components had to be changed during the conversion from TSAMB to RSA out of the 14 cases because of loosening in glenoid type B2 Walch classification. Nine cases needed glenoid bone graft reconstruction (iliac crest bone in six cases, allograft in three cases) with a long peg metal back glenoid component in five cases. At final follow-up, there was no glenoid notching, no complication and no infection.

Discussion

Causes of shoulder arthroplasty revisions are variable and frequent.

A metal-backed (MB) glenoid component has been debated since Neer's experience with Mark 2 [11]. Various authors published failures [12, 13]. Nevertheless, some situations lead us to look for a new versatile MB design, including good results with RSA, high glenoid dysplasia incidence and/or glenoid bone cyst needing posterior bone graft but non-compatible with a cemented implant, failures of cemented glenoid components with more than 80 % radiolucent lines (RLL) [14]. Most of the time RLL do not show any symptoms as revision incidence is less than 5 % [15, 16]. In any case, glenoid loosening remains the main cause for revision [3, 17]. During revision, glenoid bone loss and massive rotator cuff tear (RCT) are frequently discovered [7, 8]. In such

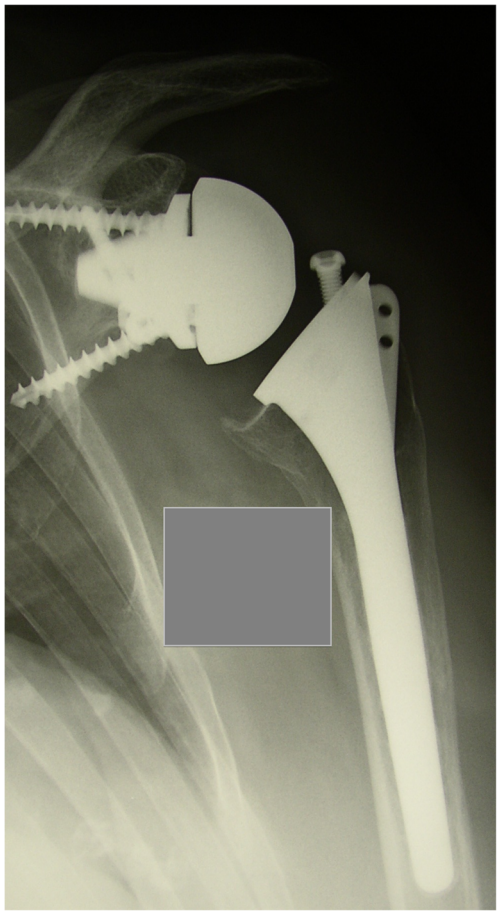

Fig. 6 RSA after switching ball and socket. There was no stem and no MB revision

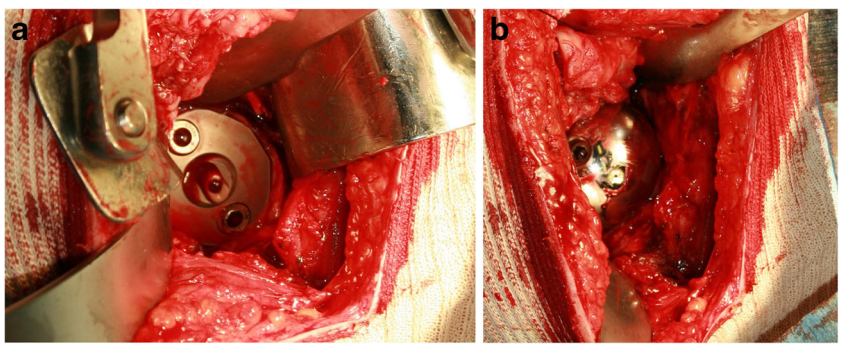

Fig. 5 **a** No MB loosening. The humeral stem and the MB glenoid component are left in situ. **b** Implantation of the glenosphere onto the same glenoid MB component

Table 2 Statistical results

Measure	Pre-operative	Postoperative	*p*
VAS	8	2	<0.001 [a]
SST	3	8	<0.001[b]
Constant score	27	60	<0.001[b]
Flexion (°)	79	124	<0.001 [a]
External rotation (°)	16	30	<0.001 [a]
External rotation 2 (°)	26	47	<0.001[b]
Internal rotation	Sacrum	L3	<0.001 [a]
Strength (kg)	2	6,5	<0.001 [a]

[a] Wilcoxon rank test

[b] Student *t*-test

anatomical conditions re-implantation of reverse shoulder arthroplasty (RSA) is recommended with glenoid bone reconstruction. Revision with the help of a long stem non-cemented glenoid reconstruction component associated with a bone graft can solve the difficult challenge of cemented glenoid loosening [18]. We report eight cases of cemented glenoid loosening needing revision with MB, and each time glenoid iliac crest graft reconstruction was needed, with a standard MB component in two cases and a special long-peg MB revision component in six cases. Conversely, we switched 12 TSAMB to 12 RSA without any MB glenoid component revision, as it was versatile. The causes of TSAMB revisions were rotator cuff re-tear in seven cases and instability in five cases. Only two TSAMB loosening needed glenoid reconstruction with glenoid bone graft and standard MB component for one and MB long peg component for the remainder. There were no failures at the junction metal/PE in any of the MB components. It is only 2.5-mm thicker than the full-cemented PE that cannot induce any subscapularis tear. There was no MB loosening at the last follow-up.

TSA instability may be a cause for revision as well. The impact of instability is estimated at 4 % [19]. It may be secondary to implant-malposition requiring revision but it may be secondary to subscapularis re-tear, axillary nerve lesion or wide bone resection. In our experience five TSAMB were revised because of anterior instability in two cases and posterior instability in three cases. Anterior instability was correlated and/or combined with subscapularis re-tear. Posterior instability occurred in case of glenoid B2 Walch classification. Revision to RSA provided a solution to these complications and surgery was easier as the MB versatile glenoid component was not changed.

Humeral stem loosening is rare [9, 20] because it is fully integrated. As anatomical stem revision is required for a RSA re-implantation and makes surgery more demanding; various authors have shown a 20–25 % humeral fracture incidence while the stem is being changed. Humeral shaft corticotomy or distal shaft window is sometimes justified as an option through the distal extended deltopectoral approach. Cerclage wire may be required to stabilize the diaphysis osteotomy. In addition there is also a risk of diaphysis perforation or for the cement to run away. In our experience 11 humeral stems had to be changed out of our 29 cases. Four humeral stems were initially lost (two lost with infected stems, one lost without infection and one humeral shaft fracture) and then were easy to change. Seven humeral stems (24 %) had to be changed due to excessive stress on the glenosphere at the time of the RSA reduction. As the inclination angle of the versatile anatomical stem is 135°, we used an intermediary device to switch for the 155° inclination angle of the RSA. This device could not correct the initial −20° retroversion of the anatomical stem because it is too thick. Therefore we tolerated these −20° retroversion with our RSA instead of the −10° proposed in primary RSA at the very beginning of our experience. Nowadays, we propose −20° retroversion in primary RSA to get more external rotation. In the remaining 25 cases, 18 anatomical versatile stems (72 %) were left to get RSA. Nevertheless, for these seven humeral stem changes we did not need any humeral shaft corticotomy and/or distal window because only the third proximal part of the stem has a surface treatment for bony integration that makes humeral stem extraction easier.

Complex fractures of the shoulder are still a real surgical challenge to be met with and lead to tuberosity malposition and/or nonunion despite specific trauma hemi-arthroplasty development with high risks of subsidence as well. Survival rate is 50–80 % [21–23]. We revised four cases (13.7 %) of glenoiditis and one case of tuberosity osteolysis. The platform system allows us to leave the anatomical versatile stem to switch for RSA for each patient.

RCR re-tear seems underestimated at 1.3 % as two recent publications make it a major cause for revision [7, 24]. We report ten cases (out of 29) of TSA revision due to rotator cuff re-tear (subscapularis tear excluded). It is for us the main cause for our revisions (34.4 %). Furthermore, subscapularis re-tear occurs in 9 % of our cases leading to anterior and superior humeral head escape. Revision surgeries were much easier, resulting in a short operative time, few intraoperative complications and a satisfactory clinical outcome at medium-term follow-up (Figs. 1–5).

Castagna et al. [25] had the same experience with 26 cases. Constant score was 26 before surgery and 47 at review. Improvement was significant regarding pain, ADL and forward flexion. Using a full modular system at the time of the first implant allows avoidance of the step to remove the humeral stem and metal back in cases of shoulder prosthesis revision to a reverse prosthesis. Nevertheless, he did not describe any issue with the level of the stem in case of conversion.

Conclusion

A shoulder platform system leads to less demanding surgery, which is less time consuming with fewer complications, avoiding stem and/or glenoid MB component revision whilst switching from anatomical to reverse arthroplasty. Nevertheless, switching was not possible in 24 % of our cases because of the size of the intermediary device, which is too big and non-compatible with narrow space.

Conflict of interest

All co-authors state that the article is original, that it is not under consideration by another journal, and that it has not been previously published. We certify that there is conflict of interest with financial organisation regarding the material discussed in the manuscript. The authors Jean Kany, Denis Katz and Philippe Valenti are originators of the system, receive royalties and are consultants for FH Orthopedics.

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