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Original Research

Free Hip Arthroplasty Templating Software - Does it Work?

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ABSTRACT

Background: Preoperative planning is important for successful total hip arthroplasty (THA) and has been historically performed using acetate templates. Digital software templating has been adopted for evaluating implant size, position, and alignment. Commercial software can be expensive, but free programs exist. Detroit Bone Setter (detroitbonesetter.com, Detroit, MI) is a freely available templating program, but hasn't been validated. Our study reports this program's accuracy for templating THA.

Methods: Sixty-five patients undergoing THA between 2017 and 2022 at 2 hospitals were included. All cases were templated by the senior author or orthopaedic trauma fellow prospectively or retrospectively in a blinded fashion. Direct anterior or posterior approaches were used based on attending surgeon's preference. A student's t-test was used to compare means of templated vs actual implant sizes of femoral and acetabular components.

Results: There was no significant difference between implanted (mean [M] = 6.4, standard deviation [SD] = 2.0) and templated femoral component sizes (M = 5.7, SD = 2.1). There was a significant difference between implanted (M = 57.0, SD = 3.9) and templated acetabular component sizes (M = 53.4, SD = 3.0). Bland-Altman testing demonstrated femoral components with positive measurement bias of 0.62, indicating slight overestimation of implant size. Acetabular component size was overestimated with positive measurement bias of 3.6 mm.

Conclusions: Detroit Bone Setter is advantageous as it is freely available and supports most major company implants. It accurately templated femoral component size but consistently overestimated acetabular component size by 3.6 mm. Further studies are needed prior to recommending its routine use for templating THA when other validated methods exist. It could be used with caution when no other methods are available.

Introduction

In the United States, approximately 438,000 total hip arthroplasties (THAs) are performed annually, according to 2009 data [1]. Projections estimate that this number could increase to 572,000-1,385,000 by 2030 and 1,429,000-1,649,000 by 2040 [2–5]. This growth could be attributed to an aging population and increasing rates of arthritis in younger patients due to obesity. Obesity and age are risk factors for developing osteoarthritis, which is the most common reason for undergoing THA [6–11]. Obesity has been increasing at an annual rate of 50% [11]. It is estimated that 42.5% of American adults aged 20 years or older are obese. Additionally, prevalence of obesity is 35% or greater in 12 states, which is an increase of 9 states from 2018 [6,12]. One study found a dose-dependent relationship between body mass index and risk of hip osteoarthritis with a 5-unit increase in body mass index being associated with an 11% increased risk of hip osteoarthritis [9]. A systemic review by Haynes *et al.* [7] of prospective studies of primary THAs in obese patients found that obesity was associated with a significantly younger age at time of primary THA (9 years younger in the morbidly obese and 2 years younger in the obese) and higher rates of perioperative complications, specifically infection and dislocation.

THA is a common treatment choice due to patient satisfaction and positive outcomes as a result of reduced pain and improved function, which have been found in the short-term, long-term, and systemically reviewed literature [13–21]. Gogia *et al.* [18] found

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that 91% of patients who underwent THA for osteoarthritis followed by physical therapy reported “excellent” outcomes and improvements in activities of daily living of 56% and 64% at 3- and 6-month follow-up, respectively. A study of the Australian arthroplasty registry containing patient-reported outcome measures 6 months following THA found that patients experienced improvements in pain, function, and health. It was also found that 86.5% of patients were satisfied or very satisfied with their THA, and 92.6% stated their joint was “much better” following THA [14].

Longer-term studies are consistent with the short-term literature. Nilsdotter *et al.* reported that patients had similar quality of life patient-reported outcome measures except for function 3.6 years following unilateral primary THA for osteoarthritis. A study examining the return to activity levels in patients younger than 60 years undergoing THA with an average follow-up of 5 years found patients had improved activity levels, and 94.4% of males and 52.3% of females returned to work. The same study also reported a correlation between patient satisfaction and activity level [16]. Studies have examined the effects of THA on hip pain and use of analgesics. Visuri *et al.* [19] reported that at a mean follow-up of 4.2 years, regular users of analgesics had decreased from 75% to 17%, and usage declined from daily to weekly. Long-term survivorship of THAs have been shown to be greater than 93% at 5-year and 10-year follow-up across multiple countries [15,22].

Systemic reviews report similar findings to the short-term and long-term literature. A systemic review of obese and nonobese patients that were at least 1-year post-THA (range: 1-20 years) reported that THA resulted in significant pain reduction and improved patient quality of life. However, long-term functional outcomes were lower in obese patients [13]. Another study examining outpatient THA with a follow-up period ranging from 4 weeks to 10 years found that at 6 weeks postoperatively, 3 studies reported excellent and 1 reported fair Harris hip score at 4 weeks postoperatively. In addition, 2 studies reported that patients had reduced pain at rest and during activity. Seven studies reported that 88.1% of patients were discharged same day. Six studies examining readmission rate showed a total of 2 (0.34%) readmissions occurred within 3 months of surgery [20]. In a systemic review of 32 articles conducted by Mei *et al.* examining the outcomes of THA in patients younger than 55 years, primary THA survivorship at 5-year and 10-year follow-up was 98.7% and 94.6%, respectively. In terms of improved function, Harris hip score increased by 47.4 points from 43.6 preoperatively to 91.0 postoperatively. Merle d’Aubigné score increased by 7.1 points from 8.9 preoperatively to 16.0 postoperatively [21].

An important part of THA success is preoperative planning, particularly the templating process, which improves operative efficacy, patient outcomes, and complication rates [23–25]. González Della Valle *et al.* [23] found that preoperative planning was useful in predicting implant size, position, and alignment, which aided in the restoration of the center of rotation of the hip and reduced the limb length discrepancy to a minimum of 1.71 mm. In a series examining 100 consecutive primary THAs, Eggli *et al.* [25] reported the correct prosthesis was implanted 98% of the time, and agreement between the template and implant for the femoral and acetabular components was 92% and 90%, respectively. In addition, preoperative planning allowed for anticipation of 80% of operative difficulties. In the trauma setting, one study found that patients suffering from femoral neck fractures who underwent preoperative planning for THA using digital radiographic templating had significantly lower limb length discrepancy than the control group [24].

Preoperative planning has historically used acetate films. However, more recently, digital templating software has become widely adopted in the preoperative process and has been shown to be safe and accurate [26–30]. One study comparing the preoperative use of acetate films in 250 THAs vs digital templating using the Sectra Ortho Station (Shelton, Conn) reported the templating software was not more accurate than acetate films but were acceptably safe in 50 THAs. The software predicted acetabular cup size to within 1 size in 60% of cases compared with 78% of cases using acetate films. In terms of the femoral stem, the templating software predicted within 1 size in 74% of cases vs 77% in cases that used acetate films. In addition, the digital templating software was found to significantly overpredict acetabular cup size and underpredict femoral stem size [26]. However, other studies report more positive findings on the accuracy of digital templating. Multiple reports using different templating software found digital templating predicts 85%-98% femoral components to within 1 size and 78%-80% acetabular components to within 1 size [27–29]. In addition, one study found that using digital templating resulted in a mean postoperative lower limb discrepancy of +0.05 mm [28]. A retrospective study of digital templating in 620 uncemented THAs conducted by Dammerer *et al.* [30] found that digital templating was exact in 52% of femoral stems and 51% of acetabular cups and predicted 90% of femoral stems and 85% of acetabular cups to within one size.

While digital templating was initially adopted to cut material costs by reducing acetate film use, templating software can cost thousands of dollars. In addition to the up-front costs, some programs require recurring licensing fees that further increase costs over time. The use of freely available templating programs may provide substantial cost savings while still allowing the surgeon to template component size and position prior to surgery. It is also easily accessible and does not require hospital integration making it available from any device at any location. However, this particular program (Detroit Bone Setter) has not been validated as a reliable templating method.

The aim of this study is to report the accuracy of the freely available Detroit Bone Setting templating software for THA.

Material and methods

This was an institutional review board-approved study of 65 patients from 2 hospitals between 2017 and 2022 who underwent THA with Detroit Bone Setter (www.detroitbonesetter.com, Detroit, MI) used for templating. All cases were templated by the senior author or an orthopaedic trauma fellow. Templating was performed in a blinded fashion either retrospectively or prospectively. The surgical approach was based on surgeon preference and was either direct anterior or posterior.

The process of templating (Fig. 1a-e) began with choosing the best available anterior to posterior x-ray of the pelvis or hip. The snipping tool was used to remove all patient identifying information from the x-ray after it was saved as an image to be uploaded into the templating system. This image was then imported into the Detroit Bone Setter software program, and scaling was performed. The templating software allows for scaling through 2 methods to correct for radiographic magnification. The first method uses an inexpensive (US $5.00 at the time of the study), commercially available, coin-shaped marker that is 25 mm in diameter and was placed at the level of the bone when obtaining the x-ray. The software then automatically detects the marker and scales the implant templates to the x-ray based on the size of the marker. The second method allows the user to specify a 10-cm length via a vertical digital ruler that is included on the x-ray. This ruler was matched to a vertical 10 cm ruler in software to adjust for magnification differences. Company-specific implants were chosen, and acetabular and femoral component sizes were templated. Templated sizes were documented and later compared to actual implant sizes used. At the time of templating, investigators did not

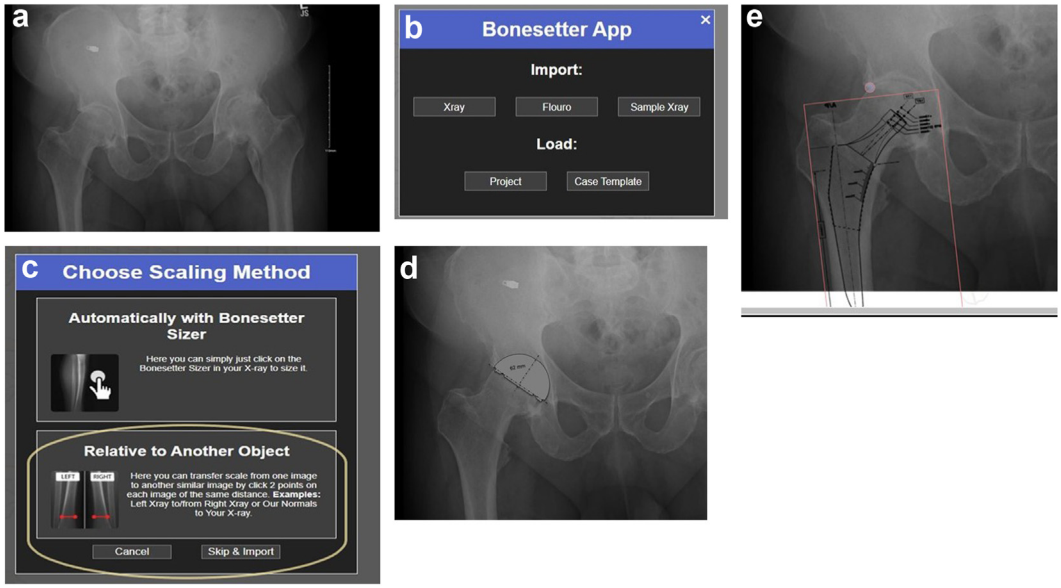

Figure 1. Steps to templating using Detroit Bone Setter. (a) Choose best available X-rays with digital marker, use snipping tool to take a picture. (b) Import X-ray picture into bonesetter. (c) Autoscaling with metal marker or manual scale using digital marker (vertical ruler). (d) Template for acetabular cup. (e) Template for femoral stem.

have access to implant sizes used even when templating was performed retrospectively.

Data analyses were performed using XLStat. A student's t-test was used to compare the means of the templated vs actual implant sizes. A Bland-Altman test was used to compare the agreement between the templated and actual implant size. Bland-Altman test is a statistical method to measure the agreement between 2 measurement techniques. In this case, the actual implant use was considered the "gold standard" against which the templating software was measured. A post hoc power analysis was performed using G*Power 3.1.9.7 (Heinrich Heine University Düsseldorf, Düsseldorf, Germany) [31]. Post hoc power analysis using a 2-tailed test, an effect size of 0.50, an alpha of 0.05, and with a sample size of 65 achieved a power of 0.81, which indicated the sample size was sufficient to render the study results statistically significant.

Results

Sixty-five patients met the inclusion criteria and were included in the study. The mean templated femoral stem size was 6.4 mm (standard deviation [SD] = 2.0), and the mean size of the actual implanted stem component was 5.7 mm (SD = 2.1). There was no statistically significant difference between the templated and implanted femoral stem sizes ($P = .068$, confidence interval = [−0.5, 1.4]). The femoral component was templated to within 1 size in 47 (72.3%) cases. The templated acetabular component for THA had a mean of 57.0 mm (SD = 3.9), while the implanted component had a mean of 53.4 mm (SD = 3.0). There was a statistically significant difference between the templated and implanted acetabular components ($P < .0001$, confidence interval = [2.4, 4.8]) (Figs. 2 and 3). The acetabular component was templated to within 1 size in 28 (43.1%) cases. A Bland-Altman test showed a positive measurement bias of 0.62 mm, indicating that the templating software slightly overestimates the femoral implant size compared to the actual implant (Fig. 4). The Bland-Altman test of the acetabular components also showed a positive measurement bias of 3.6 mm when templating acetabular components, meaning that the templating system tended to overestimate the required size of the acetabular components (Fig. 5). Intraclass correlation coefficient was calculated to determine agreement between the 2 different surgeons' templated values. A value of 0.57 was obtained suggesting moderate agreement.

Discussion

Preoperative planning has played an important role in the success of THAs. The templating process has improved operative efficacy, patient outcomes, and complication rates [23–25]. Historically, acetate films have been used in the preoperative planning process. As technological advances have been made, digital templating software has become more widely adopted and has been shown to be safe and accurate [26–30]. Eggli *et al.* [25] reported correct prosthetic implantation 98% of the time. Accuracies between the templated vs implanted femoral and acetabular components were 92% and 90%, respectively. Another study

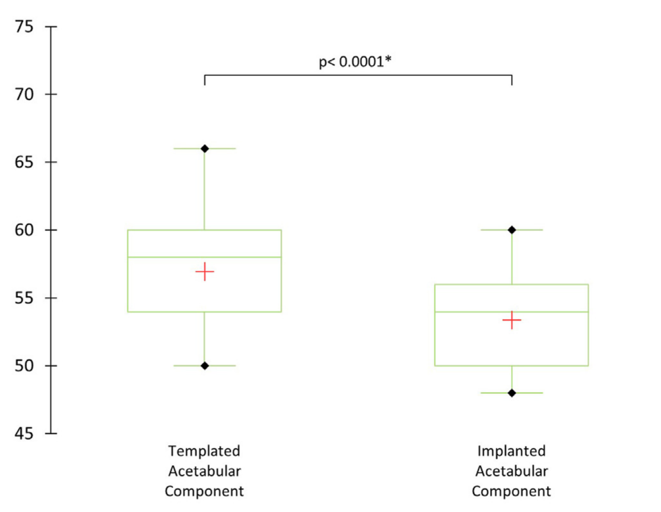

Figure 2. Templated vs implanted acetabular component sizes.

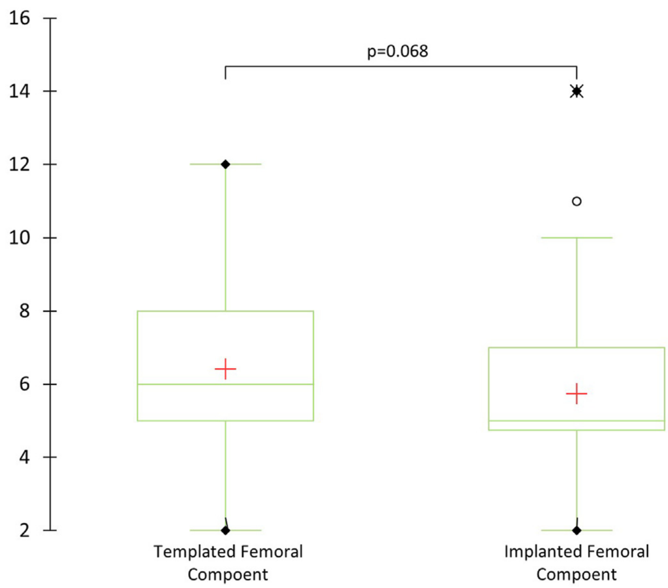

Figure 3. Templated vs implanted femoral stem sizes.

comparing preoperative acetate films in 250 THAs vs digital templating using Sectra Ortho Station in 50 THAs reported the templating software was not more accurate than acetate films but was acceptably safe [26]. Further studies using different templating software found digital templating predicts 85%-98% femoral components to within 1 size and 78%-80% acetabular components to within 1 size [27–29].

There are multiple options when deciding which digital templating platform to use. However, they are expensive due to costs for the software itself and any proprietary hardware or recurring licensing needed. Freely available templating software is an alternative to costly, proprietary software. Not only is Detroit Bone Setter free, but it is easily accessible from all devices such as iPads, tablets, computers, and phones. This software requires the radiograph to be imported into the system, which can be done remotely or while at the hospital. Other digital software requires integration to be performed on hospital premises or cloud-based PAC systems, which limits templating to be performed while in-house. Detroit Bone Setter can be used from any setting, which makes it a valuable learning tool for residents and fellows as they can prepare for surgical cases from any environment. Detroit Bone Setter is also a valuable tool for surgeons who travel abroad to provide care to underserved areas of the world, as they can use their personal device to import images taken there and perform templating.

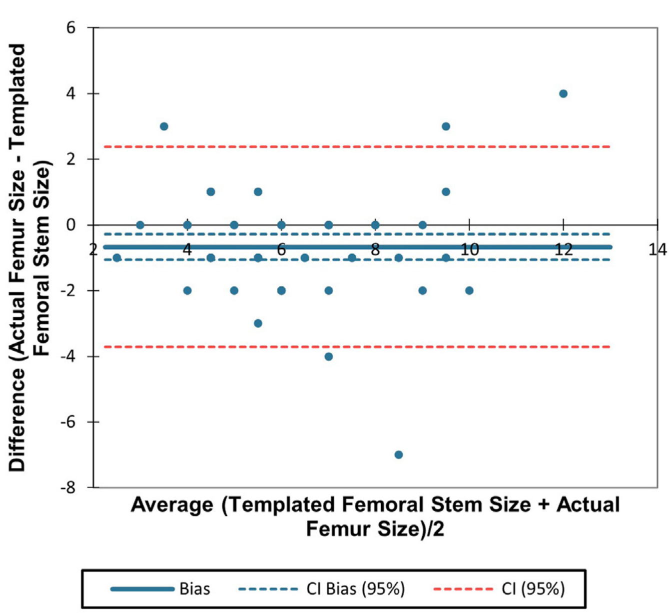

Figure 4. Bland-Altman plot of templated vs implanted femoral stem sizes.

This study evaluated whether there was a significant difference between size of components that were templated using the freely available software Detroit Bone Setter and actual implants used during operative intervention. There was no significant difference between the templated and implanted femur size. This suggests accurate preoperative templating when compared to actual implant size used on the femoral side of the arthroplasty. Bland-Altman testing showed only a slight overestimation of size, which is within the acceptable range. In regard to the acetabular component, there was a significant difference between actual and templated sizes. Additionally, the Bland-Altman test showed that there was an overestimation of size when the templating software was used by 3.6 mm. Iorio *et al.* [26] found similar results with the digital templating software Sectra Ortho Station (Sectra, Shelton, Connecticut, USA), demonstrating significant overprediction of the acetabular cup size and underprediction of the femoral stem size. There are multiple reports that other digital templating software predicts 85%-98% femoral components to within 1 size and 78%-80% acetabular components to within 1 size [27–29]. Overall, this study shows comparable estimation trends as seen in other digital software in regards to femoral sizes with a power analysis that allows for proper identification of significance (Table 1).

It is important to identify limitations of this study. Some of the cases were templated retrospectively, meaning the actual implants had been implanted prior to templating. It could be thought that operative reports could be viewed prior to templating to allow for bias to be implemented. However, all templating was performed by the senior author or one orthopaedic trauma fellow, where strict blinding was performed and there was no access to operative reports. The intraclass correlation coefficient suggested moderate agreement between the individuals performing the templating in the study, which could have played a role in the inaccuracy of the acetabular templating. Retrospective templating was needed in the study to recruit as many patients as possible to increase the power of the study, which was accomplished. Additionally, the pool of patients is from 2 hospitals that includes 4 surgeons. Surgical training, component fit preference, and implant choice are present between the different surgeons, which could affect surgical outcomes. There are also limitations with Detroit Bone Setter itself as digital software. One limitation is manufacturer's and implant's availability to be used for templating. Other software has larger pool of manufacturers. However, this was not a concern for this study as surgeon manufacturer preferences were available within Detroit Bone Setter. Given the easy accessibility and free availability of Detroit Bone Setter, any surgeon can search the software to see if their preferred manufacturer and implants are available for use without any monetary investment. Another limitation of Detroit Bone Setter is that it does not integrate with the hospital picture archiving and communications system. As discussed prior, radiographs have to be imported into the system. This could be thought to lead to improper rendering of the radiograph and cause for errors in measurements. However, the inexpensive coin-shaped marker provided within Detroit Bone Setter mitigates measurement error. As discussed before, by not integrating with the hospital PAC systems, Detroit Bone Setter can be

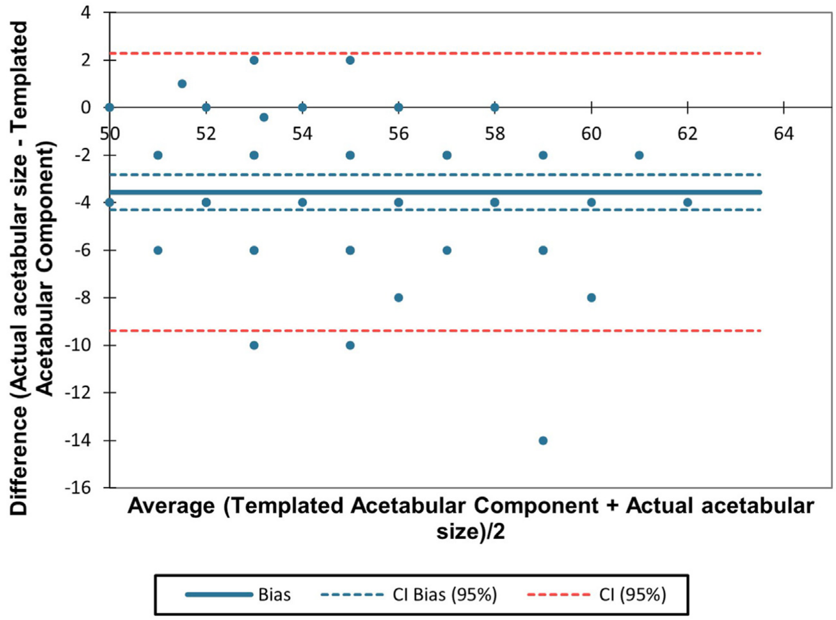

Figure 5. Bland-Altman plot of templated vs implanted acetabular component size.

accessed from any environment on any device making it advantageous. Further studies that collect data from additional patients, surgeons, and institutions are needed to further explore the accuracy of this freely available templating software. Despite these limitations, this study demonstrates promising findings in the accuracy and adequacy of Detroit Bone Setter in the preoperative planning for THA.

Conclusions

Proprietary templating software has been shown to be effective in templating components for hip arthroplasty, but at what may be a prohibitively high cost. Freely available and easily accessible templating software is an advantageous alternative, but Detroit Bone Setter has not yet been validated for templating hip arthroplasty. To the best of our knowledge, this study is the first of its kind to provide insight into the accuracy of the Detroit Bone Setter software for templating in THA. Further studies and additional patients are needed to further validate the findings of our study. Surgeons should be cautioned that the Detroit Bone Setter software may overestimate the size of the acetabular component but appears to accurately predict the femoral component sizes in THA.

Conflicts of interest

The authors declare there are no conflicts of interest.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2023.101182.

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Table 1
Current literature of digital total hip arthroplasty templating arthroplasty software.

Author	Software	Percent of cases templated femoral component within 1 size of implant	Percent of cases templated to acetabular component within 1 size of implant
Iorio *et al.* [26]	Sectra Ortho Station	74%	60%
Whiddon *et al.* [27]	Impax	90%	78%
Shaarani *et al.* [28]	Orthoview version 2.0CEN	98%	80%
Gamble *et al.* [29]	Orthoview version 2.0CEN	85%	80%
Jouflas *et al.* [Current]	Detroit Bone Setter	72.3%	43.1%

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