Arthroplasty Today 3 (2017) 167–170

Contents lists available at ScienceDirect

Arthroplasty Today

journal homepage: http://www.arthroplastytoday.org/

Brief communication

Use of iPhone technology in improving acetabular component position in total hip arthroplasty

Xiau Wei Tay, MBBS *, Benny Xu Zhang, MBBS, George Gayagay, MBBS, FRCS, FAOrthA

Orthopaedic Department, Albury Hospital, Albury Wodonga Health, Albury, NSW, Australia

ARTICLE INFO

Article history:
Received 17 April 2017
Received in revised form
2 May 2017
Accepted 7 May 2017
Available online 24 June 2017

Keywords:
Total hip arthroplasty
Total hip replacement
iPhone
Smartphone
Acetabular cup
Target angles

ABSTRACT

Improper acetabular cup positioning is associated with high risk of complications after total hip arthroplasty. The aim of our study is to objectively compare 3 methods, namely (1) free hand, (2) alignment jig (Sputnik), and (3) iPhone application to identify an easy, reproducible, and accurate method in improving acetabular cup placement. We designed a simple setup and carried out a simple experiment (see Method section). Using statistical analysis, the difference in inclination angles using iPhone application compared with the freehand method was found to be statistically significant ($F[2,51] = 4.17$, $P = .02$) in the "untrained group". There is no statistical significance detected for the other groups. This suggests a potential role for iPhone applications in junior surgeons in overcoming the steep learning curve.

Introduction

Acetabular cup positioning is an important variable for the outcome of total hip arthroplasty (THA). Cup positioning is directly related to the rate of dislocation, component impingement, pseudotumors, and other complications post THA as evidenced by numerous studies [1-4]. Despite having a target angle for safe zone as described by Lewinnek et al [1], it is often difficult to achieve the angles intraoperatively due to numerous external factors affecting the proper placement of implant [5].

Numerous studies on navigation-assisted surgery, alignment jigs, surgical techniques, and smartphone applications were conducted to improve the accuracy in achieving the target angles and improve patient outcomes [6-9]. However, it is often difficult to analyze and compare outcomes from the studies due to the wide range of techniques described and methods used.

Referring to a recent study by Peters et al [8], there is potential benefit in the use of smartphone application in acetabular cup positioning. With the increased use of smartphone technologies especially in the field of orthopaedics [10,11], we aim to improve on the application suggested in the study by Peters et al [8], and to conduct a study to objectively compare the different methods currently available. We aimed to identify an easy, reproducible, and accurate method for acetabular cup placement which will overcome the steep learning curve in surgical training [12] and improve the rate of achieving target angles in THA.

Material and methods

We designed a simple setup consisting of acetabular cup impactors, laser level tripods, protractors, iPhone, alignment jig, and wheels which allow the 2-directional movement of interest (anteversion and inclination) as shown in Figure 1.

Two free iPhone applications (AngleMeter, Neko System) and (Spirit Level Made Simple, Scaleitapp Ltd) were downloaded to iPhone from the Apple Application Store (App Store). Both applications utilize accelerometer functions in an iPhone to detect movement and indicate the angles to which the iPhone was moved from default post reset. The iPhone is mounted directly onto the impactor as demonstrated in Figure 2.

Ten medical doctors of different skills and experience levels (1 consultant, 3 registrars, 2 residents, and 4 interns) were invited to participate in this study. The assessor (one of the author of this article) will start by explaining and demonstrating the process of the experiment. The participants were invited to stand on one side of the

No author associated with this paper has disclosed any potential or pertinent conflicts which may be perceived to have impending conflict with this work. For full disclosure statements refer to http://dx.doi.org/10.1016/j.artd.2017.05.004.

* Corresponding author. Borella Road, Albury, NSW 2640, Australia. Tel.: +61 403 656 223.
E-mail address: xwtayxx@gmail.com

http://dx.doi.org/10.1016/j.artd.2017.05.004

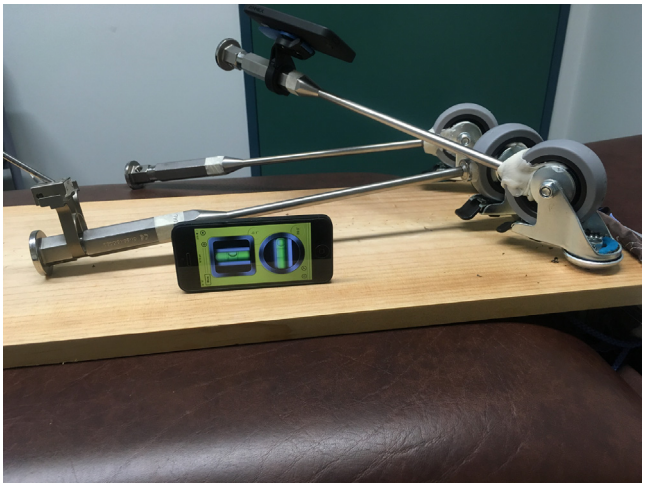

Figure 1. Simulated set-up with 3 acetabular cup impactors cemented on swivel castors with brakes, mounted on a flat piece of wood leveled using electronic level application on iPhone.

"operating table" where the setup lays and were asked to maneuver the impactor in the different directions as indicated. The setting is that of the "patient" lying on the left lateral position and the angles of interest are therefore the inclination and anteversion angles measured via methods detailed in the following. Participants were given time to familiarize with the simulated setup and the 3 methods of interest, namely (1) freehand, (2) alignment jig (Sputnik) use, and (3) iPhone application guidance were demonstrated. Attempts were made to achieve a target angle of (1) 45° inclination and (2) 15° anteversion. Once attempts were made, the assessor would project the angles of interest using 2 laser pointers (one each for inclination and anteversion) while the participants were to continue holding the impactor. This was achieved by aligning the laser beam to lie along the axis of the impactor as shown in Figure 3. There are large sheets of graph papers pasted on the background on both walls which were leveled to the "operating table" before the start of any attempts. The angle of the impactor, which is represented by the angle of the laser beams on the graph papers, was then measured by hand using a protractor (see Fig. 4). Three attempts were performed for each participant, with a minimum of 15 minutes gap in between attempts to minimize muscle memory and bias.

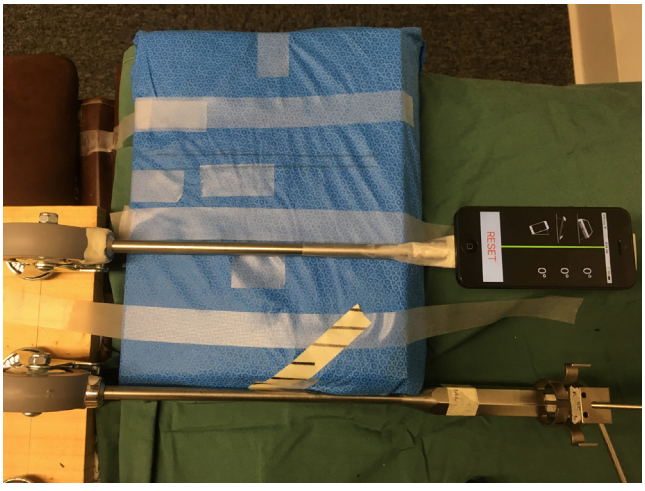

Figure 2. iPhone mounted on impactor (top) and Sputnik (alignment jig for 45 degree inclination and 15 degree anteversion) attached on impactor (bottom).

Figure 3. Laser beam aligned along the axis of the locked impactor and projected onto the sheets of graph papers in the background which were leveled to the "operating table" (using the SpiritLevel iPhone application).

Results

The data collected were analyzed using MATLAB (The MathWorks, Inc., Natick, MA). The average angle of inclination across all participants using freehand, Sputnik, and iPhone were 46.96°, 45.88°, and 45.21°, respectively. The standard deviations (SDs) of inclination angle were 5.69° in the freehand group, 2.56° in alignment jig, and 0.96° in iPhone. The mean angles of anteversion were 14.77° (SD, 4.8°) using freehand, 14.46° (SD, 3.71°) using Sputnik and 14.75° (SD, 1.66°) using iPhone (Table 1).

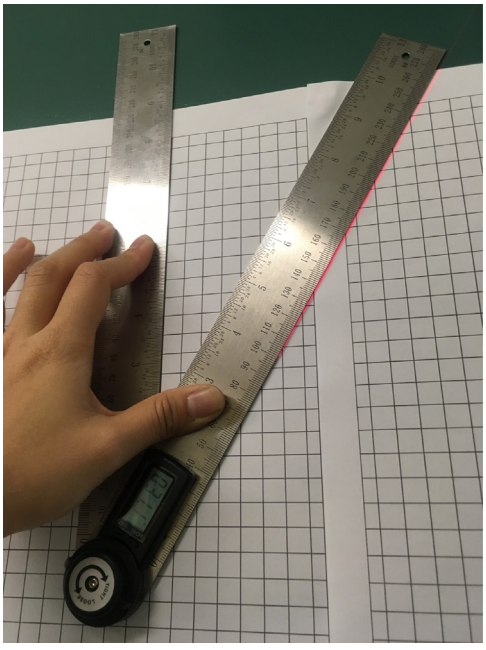

Figure 4. The figure demonstrates a measurement of the projected angle using a ruler with digital protractor.

Table 1
Inclination and anteversion angles for all participants.

Methods	Angels	
	Inclination	Anteversion
Mean		
Freehand	46.96	14.77
Sputnik	45.88	14.46
iPhone	45.21	14.75
Standard deviation		
Freehand	5.49	4.80
Sputnik	2.56	3.71
iPhone	0.96	1.66

One-way analysis of variance to compare inclination and anteversion angles among the 3 methods showed a *P* value of .18 and .94, respectively (Figs. 5 and 6).

We also performed subgroup analysis of "trained" and "untrained" group, where registrars and consultants are included in the "trained" subgroup. The mean and SD of "trained" and "untrained" group are shown in (Tables 2 and 3).

Using 1-way analysis of variance and Tukey's honestly significant difference post hoc test on the "untrained" group, the difference in inclination angles using iPhone application compared with the freehand method was found to be statistically significant ($F[2,51] = 4.17$; $P = .02$; Fig. 7). There is no statistical significance detected for both anteversion (P value $= .94$) and inclination (P value $= .64$) in the "trained" group, as well as in anteversion for "untrained" group (P value $= .95$).

Discussion

Smartphone applications are easy, cheap, and quick to use in providing objective and real-time measurements using its accelerometer, protractor, and level functions. We hypothesized that with these applications, acetabular cup placement could be improved and will be more reproducible in all surgeons with different skills and experience levels. We acknowledge that this study might be oversimplifying the technical difficulties in acetabular cup placement intraoperatively because of different factors including patient positioning, anatomic variations, and perioperative pelvic tilt. However, the aim of this study is to objectively identify an easy, accurate, and reproducible method which could be used to achieve a specific target angles as determined by the surgeon during the operation based on individual patients.

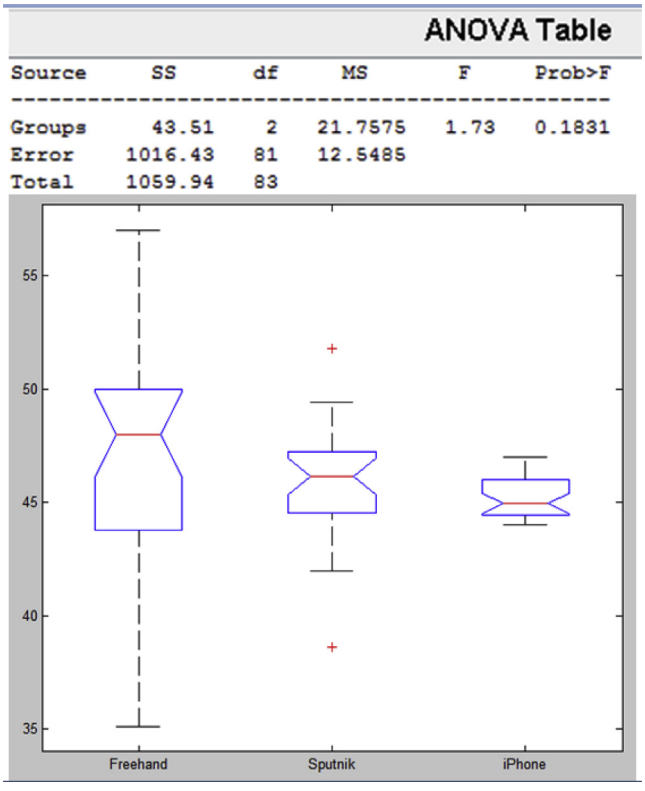

Figure 5. Analysis of variance (ANOVA) analysis for inclination angles comparing 3 methods in all participants.

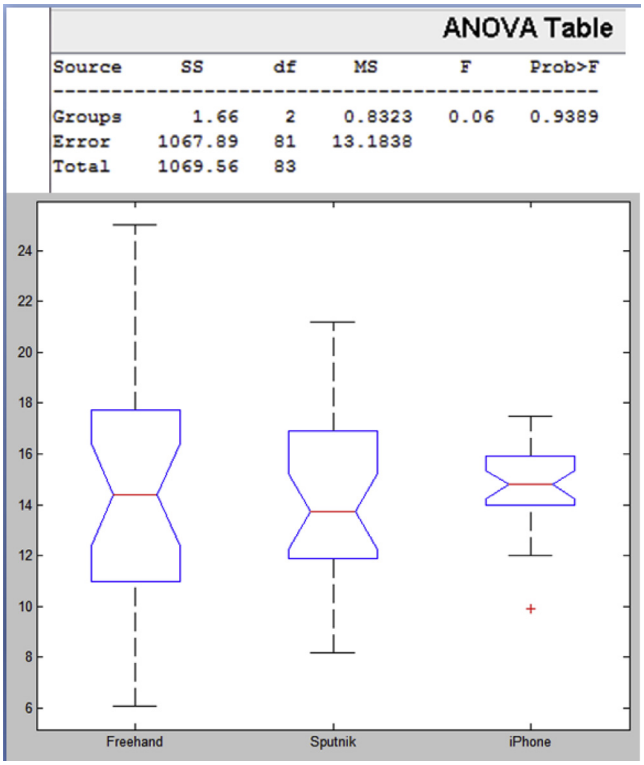

Figure 6. ANOVA analysis for anteversion angles comparing 3 methods in all participants.

From our results detailed previously, we found that "untrained" junior medical staff performed significantly better in estimating the inclination angle using the iPhone application compared with the freehand method ($P = .02$). This suggests a potential role for the usage of iPhone applications by junior surgeons or trainees to assist in overcoming the steep learning curve of achieving the target angles more accurately.

However, there is no statistically significant difference in estimating the anteversion angle by all participants and

Table 2
Mean and standard deviation for inclination and anteversion angles for "Trained group".

Methods	Angels	
	Inclination	Anteversion
Mean		
Freehand	44.09	14.47
Sputnik	45.50	14.34
iPhone	44.78	14.88
Standard deviation		
Freehand	5.21	4.00
Sputnik	2.18	4.37
iPhone	0.87	1.88

Table 3
Mean and standard deviation for inclination and anteversion angles for "Untrained group".

Methods	Angels	
	Inclination	Anteversion
Mean		
Freehand	48.55	14.94
Sputnik	46.08	14.53
iPhone	45.45	14.68
Standard deviation		
Freehand	5.10	5.29
Sputnik	2.78	3.43
iPhone	0.94	1.57

subgroups using the 3 methods. Our findings are similar to that in the study by Peters et al [8,13], where there is lack of statistical significance in iPhone application in assessing anteversion angles.

There are several limitations in our study. First, our sample size was small in the "trained" group, leading to potential sampling bias. However, the subgroup of interest in this study is the "untrained" group, and our focus is to demonstrate and compare the 3 methods in aiding surgical trainees of limited experiences in achieving target angles. Second, our study method used to measure the angles does not necessarily represent the radiographic or

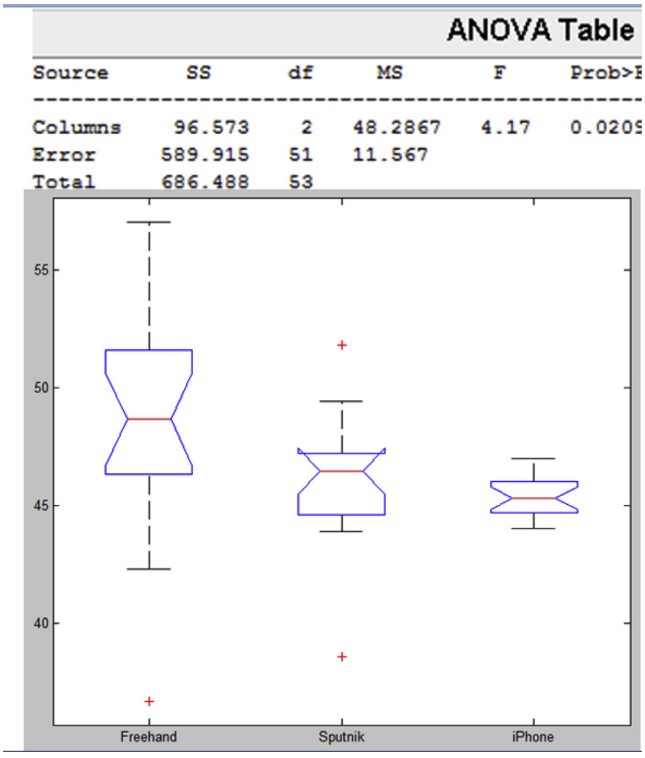

Figure 7. ANOVA analysis for inclination angles comparing 3 methods in "Untrained group."

postoperative outcome of acetabular cup positioning [14]. Nonetheless, it is an objective and simple way to compare the 3 methods available to achieve specific target angles intraoperatively. Third, the measurement of the anteversion angle using a laser projection anteriorly is only an approximation of the true anteversion angle described by Lewinnek et al [1]. We acknowledge that these angles achieved using our simple set-up might not translate into radiographic or clinical outcomes of the hip arthroplasty; however, this project serves as a pilot study for further projects where this technology may be implemented in real clinical practice.

Conclusions

Accurate acetabular cup positioning is a crucial step during THA to minimize the risk of complications. Our study showed a statistical significance in improvement in achieving target inclination angles in "untrained" group with the use of iPhone application. We believe that there is a role for iPhone application in improving acetabular cup positioning especially in achieving a consistent inclination angle. This method is believed to be minimally invasive, less time-consuming, and cheaper than other methods such as computer navigation or computed tomography–based navigation. We hope to aim for further studies using iPhone technology in real clinical practice to assess its practicality compared with other methods.

References

[1] Lewinnek GE, Lewis JL, Tarr R, et al. Dislocations after total hip-replacement arthroplasties. J Bone Joint Surg Am 1978;60:217.
[2] Biedermann R, Tonin A, Krismer M, et al. Reducing the risk of dislocation after total hip arthroplasty: the effect of orientation of the acetabular component. J Bone Joint Surg Br 2005;87:762.
[3] Grammatopoulos G, Pandit H, Glyn-Jonce S, et al. Optimal acetabular orientation for hip resurfacing. J Bone Joint Surg Br 2010;92-B:1072.
[4] Kennedy JG, Rogers WB, Soffe KE, et al. Effect of acetabular component orientation on recurrent dislocation, pelvic osteolysis, polyethylene wear, and component migration. J Arthroplasty 1998;13:530.
[5] Jolles BM, Zangger P, Leyvraz PF. Factors predisposing to dislocation after primary total hip arthroplasty: a multivariate analysis. J Arthroplasty 2002;17:282.
[6] Domb BG, El Bitar YF, Sadik AY, et al. Comparison of robotic-assisted and conventional acetabular cup placement in THA: a matched-pair controlled study. Clin Orthop Relat Res 2014;472:329.
[7] Xu K, Li YM, Zhang HF, et al. Computer navigation in total hip arthroplasty: a meta-analysis of randomized controlled trials. Int J Surg 2014;12:528.
[8] Peters FM, Greeff R, Goldstein N, et al. Improving acetabular cup orientation in total hip arthroplasty by using smartphone technology. J Arthroplasty 2012;27(7):1324.
[9] Ranawat CS, Maynard MJ. Modern techniques of cemented total hip arthroplasty. Tech Orthop 1991;6:17.
[10] Kulendran M, Lim M, Laws G, et al. Surgical smartphone applications across different platforms: their evolution, uses and users. Surgical Innovation 2014;21(4):427.
[11] Franko OI. Smartphone apps for orthopaedic surgeons. Clin Orthop Relat Res 2011;469(7):2042.
[12] Redmond JM, Gupta A, Hammarstedt JE, et al. The learning curve associated with robotic-assisted total hip arthroplasty. J Arthroplasty 2010;30:50.
[13] Meermans G, Kats JJ. Letter regarding "improving acetabular cup orientation in total hip arthroplasty by using smartphone technology." J Arthroplasty 2013;28(7):1246.
[14] Murray DW. The definition and measurement of acetabular orientation. J Bone Joint Surg Br 1993;75(2):228.