ARTICLE IN PRESS

Arthroplasty Today xxx (2017) 1–6

Contents lists available at ScienceDirect

Arthroplasty Today

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

Original research

Radiolucencies surrounding acetabular components with three-dimensional coatings: artifact or real?

Ahmad Faizan, PhD [a,*], Philip Chuang, PhD [a], Carlos Aponte, AAS [a], Vincent Moretti, MD [b], Peter F. Sharkey, MD [b]

[a] Stryker, Mahwah, NJ, USA
[b] The Rothman Institute at Thomas Jefferson University Hospital, Philadelphia, PA, USA

ARTICLE INFO

Article history:
Received 23 April 2017
Received in revised form
20 June 2017
Accepted 20 June 2017
Available online xxx

Keywords:
Cementless fixation
Radiolucency
Cadaver study
Bone apposition
Artifact

ABSTRACT

Background: Several 2-dimensional and 3-dimensional surfaces are available for cementless acetabular fixation. Plain radiographs are used to assess osseointegration; however, the radiographs are limited by their inability to capture the bone fixation process occurring over the 3-dimensional cup surface. In this cadaveric study, we compared the bone apposition between 2-dimensional and 3-dimensional cups.
Methods: Both types of cups were implanted in 6 cadavers and pelvic radiographs obtained. Each cup was resected from the pelvis with adequate bone around it, and subsequently embedded in a polymer. Six sections of each cup were obtained to examine the metal and bone interface. Photographs and contact radiograph images were obtained for each section, and these were graded to arrive at percent metal-bone contact values for the cups.
Results: On average, <30% of the cups' areas displayed radiolucencies on the pelvic radiographs for both cup types. For the section images and radiographs, there was about 80% aggregate contact between the cups and surrounding bone in both cup types. In the 3-dimensional cups group, some inconsistencies were found between the section photographs and the corresponding radiograph images. The radiolucencies observed on the section radiograph could not always be correlated with metal to bone gap on the section photograph.
Conclusions: Good metal-bone contact (75% + contact area) was observed on both cup types. The inconsistencies found in the 3-dimensional cup group may be because of the interaction of radiographs with the unique porous cup surface resulting in artifactual radiolucencies.

Introduction

A variety of 2-dimensional (2D) and 3-dimensional (3D) surface modifications of the acetabular cups are available to surgeons [1,2]. The prime aim of these modified surfaces is to improve the biological fixation between the metallic cup and the surrounding bone. However, evaluating or recognizing true biologic fixation of an acetabular component is not straightforward. Plain radiographs are typically used as an indirect surrogate marker of biological fixation between the cup and surrounding bone [3-6]. In post-operative plain radiographs, the presence of progressive radiolucent zones of 2 mm or more around the implant in the 3 radiographic zones is reportedly indicative of aseptic loosening [6]. 2D plain radiographs have a limited ability though to quantify the extent of fixation as the biological fixation occurs in 3D space around the entire cup. Only a few researchers have conducted metal-bone contact analysis on retrieved acetabular cups to gain deeper insight into the extent of biological fixation. Engh et al [7] attempted to quantify the biological fixation in retrieved acetabular cups and found that, on average, only 32% of the surface of the cup was in contact with the surrounding bone. In contrast, Bloebaum et al [8] published the results of their retrieval analysis of porous cups and reported an average of 84% bone apposition between the cups and surrounding bone.

In clinical practice, 2D and 3D modified acetabular components have demonstrated good outcomes and survivorship [9-17] The Trident Primary Acetabular Component (Stryker, Mahwah, NJ) has a

One or more of the authors of this paper have disclosed potential or pertinent conflicts of interest, which may include receipt of payment, either direct or indirect, institutional support, or association with an entity in the biomedical field which may be perceived to have potential conflict of interest with this work. For full disclosure statements refer to http://dx.doi.org/10.1016/j.artd.2017.06.004.

* Corresponding author. 325 Corporate Dr, Mahwah, NJ 07430, USA. Tel.: +1 201 831 5674.
E-mail address: ahmad.faizan@stryker.com

http://dx.doi.org/10.1016/j.artd.2017.06.004
2352-3441/

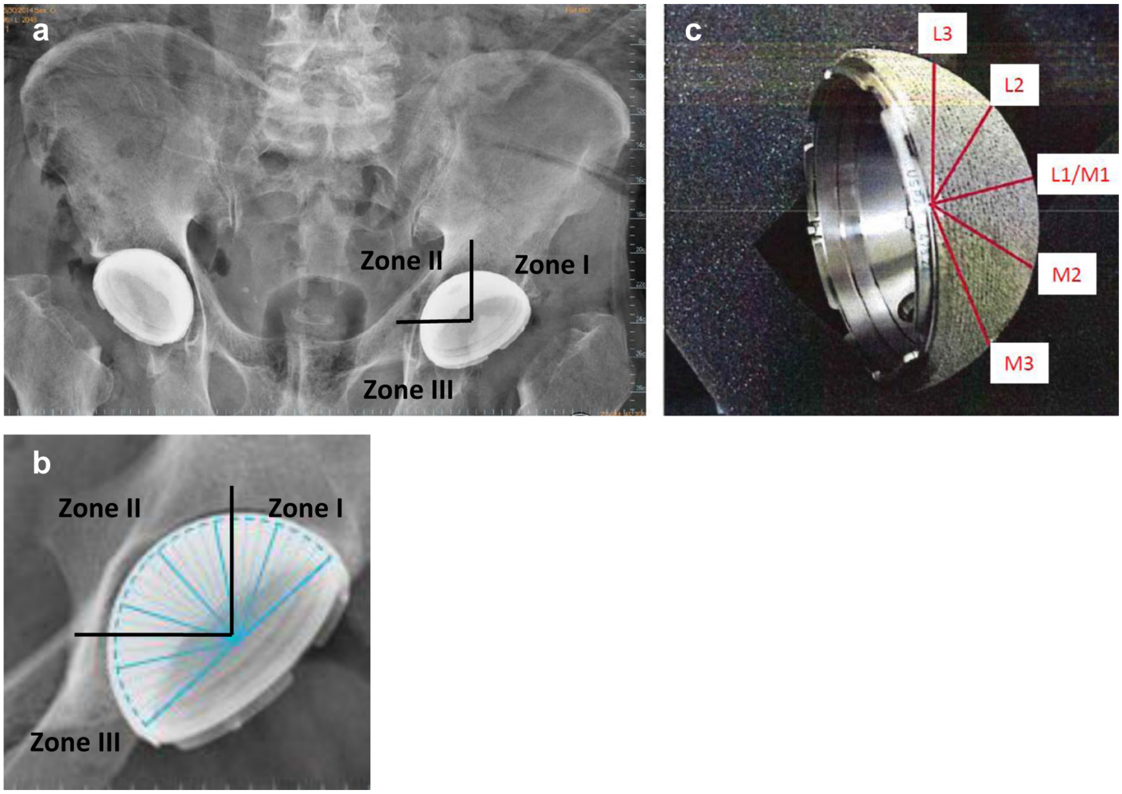

Figure 1. (a) Example of the post-operative pelvic plain radiographs obtained on each specimen. (b) Semicircle grids with 24 subsections measuring 7.5° each were superimposed onto each cup radiograph and divided into 3 zones. (c) Sectioning scheme of the acetabular cup. Six sections were generated from each cup by dividing the cup at 30° intervals (L1, L2, L3, M1, M2, M3). L3 is the lateral most section, while M3 is the medial most section. L1 and M1 are the sections in the central region of the cup; however, they are not exactly the same when we factor in the blade thickness of 0.3 mm. L2 and M2 are between L1 and L3 and M1 and M3, respectively.

2D surface coating of arc-deposited commercially pure titanium. First released in the late 1990s, the Trident has demonstrated long-term clinical success in multiple studies [10-15]. A more recently introduced device with a 3D surface is the Tritanium Primary Acetabular Component (Stryker). The Tritanium porous surface is manufactured by the deposition of commercially pure titanium onto a machined scaffold of reticulated, open cell, polyurethane foam [18]. It is designed to have high porosity and a high coefficient of friction. These properties enhance the biological fixation between the cup and the surrounding bone [19-23]. Short- to medium-term data have shown good clinical performance for this device as well [17,24,25]. However, Carli et al [26] recently reported that over one-third of 121 consecutively implanted Tritanium acetabular components, with an average follow-up of 3.9 years, had associated radiographic lucencies. These authors attributed the radiolucencies to unacceptably large regions of fibrous ingrowth. Nonetheless, in this same study, cup survivorship was an impressive 98.1% at the most recent follow-up. In a separate clinical study, Nandi performed comparative survival analysis of the porous tantalum (Zimmer Biomet, Warsaw, IN) and porous titanium (Tritanium; Stryker) acetabular components in both primary and revision total hip arthroplasty [27]. Their study concluded that there was no difference in likelihood of revision between the porous tantalum and porous titanium cups.

The discrepancy between the imaging findings and clinical results for 3D acetabular cups has not been well researched or explained in the literature. The current cadaveric study was therefore designed to better understand the differences in the radiographic and histologic bone apposition characteristics of 2D (Trident; Stryker) acetabular cups with the recently introduced 3D (Tritanium; Stryker) acetabular cups. We set out to answer the following questions:

1. Are there radiographical differences between the 2 cup types?
2. Are there differences in bone apposition between the 2 cup types from observation of the physical sections?
3. Are there differences in perceived bone apposition between the physical sections' photographic images and their radiographic images?

Material and methods

Acetabular components were implanted bilaterally in 6 fresh frozen cadavers by a single highly experienced fellowship trained arthroplasty surgeon (P. F. S.). Each specimen was laterally randomized to receive either a 2D (Trident; Stryker) or 3D (Tritanium; Stryker) surface acetabular component. The surgeon utilized a modified anterolateral approach between the tensor fasciae latae and gluteus medius muscles to access the hip joint. The hips were dislocated and an oscillating saw was used for neck resection. Final components were implanted after routine acetabular preparation, including under-reaming the acetabulum by 1 mm (targeting 45° abduction and 20° version). Satisfactory initial stability (the cup did not move when applying a considerable amount of force on the cup inserter, and therefore no need for supplemental screws) of the acetabular component was achieved in all specimens.

Following implantation, all cadaveric specimens were radiographically evaluated with a plain anteroposterior film of the pelvis (Fig. 1a). A large bone defect was found around the cup in 1 cadaver