Hydrophobic/Hydrophilic Characteristic of Titanium Surfaces: Machined, Dual Acid Etched (Osseotite ®), and Dual Acid Etched with Nanometer-scale CaP (NanoTite ™)

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Introduction: Contact angle, reported in degrees, is a measure of the wetting of a solid surface by a liquid. The objective of this study was to measure the static contact angle made by liquid media on various titanium surfaces and determine whether a given surface was hydrophobic or hydrophilic.

Materials and Methods: Custom-designed circular disks, 20mm in diameter and 1.5mm thick, were manufactured from commercially pure titanium (CP Ti) and Ti-6Al-4V-ELI alloy (Ti Alloy). Three groups of disks from both CP Ti and Ti Alloy were used: machined, dual-acid etched (DAE, proprietary to 3i), and nanometer-scale calcium phosphate hydroxide (nano-CaP) crystals deposited by a new surface treatment called discrete crystalline deposition (DCD, proprietary to 3i) called NanoTite™. Three disks from each group were evaluated for hydrophilic or hydrophobic behavior with de-ionized (DI) water, bovine blood with citrate, and bovine blood with ACD-A. The contact angle was measured using MD-OCA contact angle meter (Future Digital Scientific, NYC, NY) using SCA20 software (Dataphysics Gmbh, Germany) running on a desktop PC. The Sessile Drop method was used for recording the video of the interaction of the droplet with the surface for 20 seconds at the rate of 12.5 frames per second. The video was then analyzed for calculating static contact angle using Young - Laplace method. Five readings were taken on each disk.

Results & Discussion: The static contact angle is mainly affected by two factors, surface topography or morphology and surface chemistry. In the current study, the effect of both surface chemistry (CP Ti vs. Ti Alloy with and without nano-CaP) and surface topography (machined vs. DAE) was examined. Table 1 shows the mean contact angle for various surfaces with DI water.

Table 1. Contact Angle Measurements on Various Titanium Surfaces Using DI Water

Disk Type	CP Ti	Ti Alloy
Machined	81±2.4	72.5±1.5
Osseotite	93.1±2.9	71.8±4.3
Nano HA	92.6±5.0	121.9±3.6

Figure 1 shows graphically the data presented in Table 1. The surface can be hydrophobic or hydrophilic/wettable depending on the criteria used for defining those terms. Low values of contact angle indicate that the liquid spreads or wets well, while high values indicate poor wetting. A zero contact angle represents complete wetting. In general, a surface exhibiting contact angle <90˚ is hydrophilic and the one exhibiting contact angle >90˚ is hydrophobic (Bico J, Thiele U, Quere D, Coll & Surf A: 206, 2002, 41-46). It can be seen from Fig. 1 that machined surface (both CP Ti and Ti Alloy) and DAE Ti Alloy were hydrophilic whereas DAE CP Ti and surface with nano-CaP (both CP Ti and Ti Alloy) were hydrophobic.

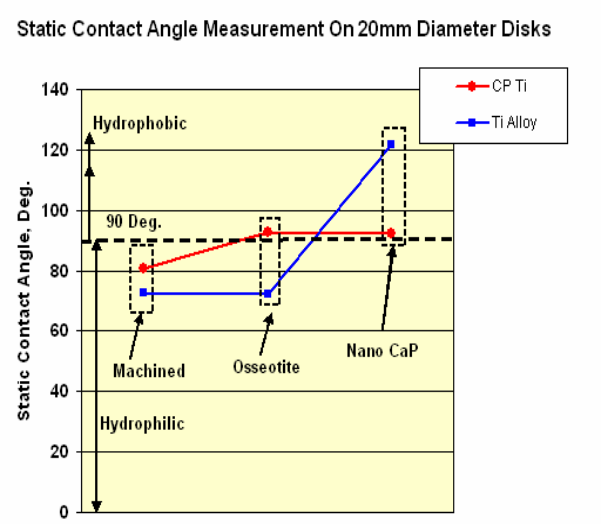

Figure 1. Graphical Representation of Contact Angle Data

Conclusions: Hydrophobic and or hydrophilic characteristics of various titanium surfaces with varying surface topography and surface chemistry were determined by measuring static contact angle.
The evaluation of the various surfaces indicates a clear correlation between the complexity of the surface topography and its hydrophilic or hydrophobic nature; the increase in surface complexity had a direct effect on rendering the surface increasingly hydrophobic.