AGE-RELATED CHANGES IN PROXIMAL FEMUR MORPHOLOGY AND HIP IMPLANT DESIGN

Tim AEJ Boymans, Ide C Heyligers and Bernd Grimm

AHORSE Foundation, Atrium Medical Center, Dept. of Orthopaedic Surgery, Heerlen, The Netherlands

email: b.grimm@atriummc.nl

INTRODUCTION

In cementless total hip arthroplasty (THA) the proximal femur morphology must be studied to achieve an optimal fit and fill of the stem during pre-operative planning (implant choice, sizing and positioning) or when a new stem is to be designed. An age related morphological transition of the endosteal canal from a 'champagne flute' to a 'stovepipe' shape (Fig. 1) was described based on simple x-rays, limited to the AP-projection and using a two-level parameter (canal flare index, CFI) only[1,2] while old age was equated to 60-80yrs. This study used computer tomography (CT) to investigate the morphological changes in 3D and extend the age range to octogenerian subjects (>80yrs), a neglected patient group of increasing demographic relevance.

METHODS

High-resolution CT-scans (slice thickness 1 mm) were made of consenting volunteers and morphologically analyzed using Mimics V12 (Materialise, Belgium). Flaring indices were defined based on dimensions measured at 20mm above the lesser trochanter (LT, level 0) and 60mm below LT (level 80): Surface CFI (3D-CFI), frontal and lateral CFI based on the projections (2D-CFI) and flaring in each of the four directions (1D-CFI, Fig. 1). Wall thickness was calculated subtracting periosteal and endosteal canal width.

A total number of 170 subjects (m/f=101/69) were scanned. The old group consisted of 119 subjects ≥80yrs (m/f=65/54, mean age: 84.1yrs [80-105]) and the young group of 51 subjects <80yrs (m/f=36/15, mean age 67.8yrs [39-79]).

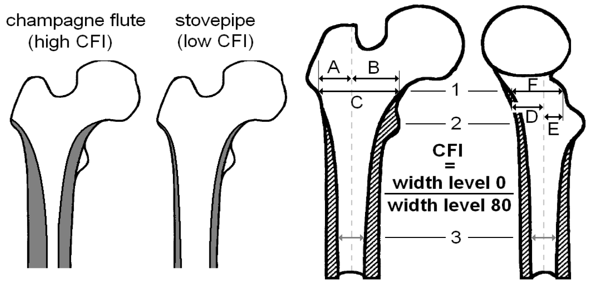

Fig. 1: Defined dimensions: A=lat; B=med; C=frontal; D=ant; E=post; F=lateral; 1=level 0; 2=LT; 3=level 80.

RESULTS AND DISCUSSION

Basic anatomical parameters such as femoral head diameter were similar to other studies[1] validating the method and a representative subject selection. The surface CFI was significantly lower in old subjects (5.08 ±1.23) than in young subjects (6.61 ±1.72, p<0.0001) showing that the age driven morphological transition of the femur continues in the very elderly. In females this difference was larger than in males (-32% vs. -17%, Fig. 2) stressing a gender difference beyond menopausal changes. Both the frontal and lateral 2D-CFI as well as the medial, lateral and anterior 1D-CFI were also significantly smaller in the very elderly than in the young showing that the age related shape transition of the proximal femur is not limited to the AP plane as previously reported[1,2] but is a 3D phenomenon. Although the CFI difference between young and old was almost equal in the frontal and lateral plane (-11.7%, -11.9%), the change was unevenly distributed per direction (e.g. anterior -26.3%, Table 1) demonstrating a highly asymmetric morphological transition of the endosteal canal which previous publications could not show. In addition wall thickness was sign. reduced in the very elderly. E.g. the medial wall at level 0 measured 10.40mm at <80yrs and 7.61 at ≥80yrs, a reduction of -27% (p<0.001). In females (-35%) this difference was sign. larger (males: -23%, p<0.001) even when corrected for height confirming the strong gender influence in bone transitions.

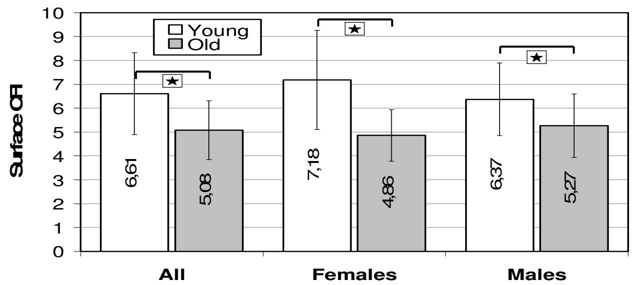

Fig. 2: 3D surface-CFI by age and gender (* p<0.001).

CONCLUSIONS

Age related changes of the proximal femur continue beyond 80yrs of age, are asymmetric, depend on gender and do not only affect the shape of the endosteal canal but also the wall thickness. With CFIs so different between normal THA patients and the very elderly, in particular in octogenarian women, an age and gender specific stem design seems necessary to achieve stable fit & fill in the morphed femur. In addition, the asymmetry of the transition prohibits the effective use of just a different size from available THA stem systems whose dimensions are proportionally scaled. A matrix sizing scheme scaling frontal and lateral dimensions independently seems more appropriate.

The data of this study can be used to built age specific FEA models and aid forensic age and gender identification.

REFERENCES

1. Noble PC, et al., *Clin Orthop Relat Res.* **235**:148-65, 1988
2. Noble PC, et al., *Clin Orthop Relat Res.* **316**:31-44, 1995

2D-CFI	Young	Old		1D-CFI	Young	Old		1D-CFI	Young	Old	
Frontal	3.42 ± *0.63*	3.02 ±*0.44*	**	**Medial**	4.26 ±1.17	3.78 ±*0.68*	*	**Anterior**	2.24 ±*0.64*	1.65 ±*0.37*	**
Females	3.73 ± *0.82*	3.02 ±*0.41*	**	Females	5.04 ±1.75	3.80 ±*0.66*	**	Females	2.25 ±*0.85*	1.68 ±*0.36*	**
Males	3.30 ±*0.49*	3.03 ±*0.46*	*	Males	3.93 ±0.59	3.76 ±*0.70*	NS	Males	2.24 ±*0.54*	1.62 ±*0.38*	**
Lateral	2.36 ±*0.40*	2.08 ±*0.29*	**	**Lateral**	2.82 ±0.76	2.41 ±*0.57*	**	**Posterior**	2.62 ±*0.68*	2.83 ±*0.98*	NS
Females	2.35 ±*0.41*	2.00 ±*0.24*	**	Females	2.91 ±0.86	2.39 ±*0.59*	*	Females	2.63 ±*0.75*	2.42 ±*0.44*	NS
Males	2.37 ±*0.41*	2.15 ±*0.31*	*	Males	2.78 ±0.72	2.43 ±*0.56*	*	Males	2.62 ±*0.66*	3.17 ±*1.16*	NS

Table 1: 2D-CFI and 1D-CFI by age group and gender (* p<0.01; ** p<0.001, NS p>0.01).