Neck Taper and Compatibility

What Does the Surgeon Have to Consider?
The Neck Taper in Hip Arthroplasty
What does the surgeon have to consider?

Leslie F. Scheuber, Sylvia Usbeck, Florence Petkow

Modular principle for hip arthroplasty

Modern hip arthroplasties are based on a modular construction. This modular construction, particularly the combination of a stem and femoral ball heads of differing neck lengths, is an accepted solution that enables flexible adjustment to the individual situation of patients during surgery.

This modularity enables the surgeon to optimize reconstruction of the original joint anatomy and to achieve the best possible biomechanics for the patient. Modular taper fixation also enables different materials such as metal and ceramics to be joined together. Taper locking has proven itself to be practicable in both its manufacturing process and its application. A further advantage is its high stability, which prevents corrosive phenomena. During revision surgery it is possible to loosen the locked fixation and to replace the femoral ball head in accordance with the manufacturer’s instructions.
On the history of taper fixation

The taper fixation between a femoral ball head and a stem, familiar in hip arthroplasty, was developed at the start of the 1970s by the industry partners Sulzer AG (endoprosthesis manufacturer and predecessor of Zimmer, Winterthur, Switzerland) and Feldmühle AG (ceramics manufacturer and predecessor of CeramTec GmbH, Plochingen, Germany).

The aim was to realize reliable and durable fixation between a ceramic femoral ball head and a metal stem. Dörre et al.\(^1\) attached special importance to the force-fit connection (taper locking) between the ceramic femoral ball head and the metal taper: a hip arthroplasty with taper fixation was used in a patient for the first time in 1974. The principle behind this taper fixation was protected in a Swiss patent (No. 1060601).

At the start of the 1990s intense efforts were made to standardize a uniform taper (the Eurotaper) with the International Organization for Standardization (ISO, document ISO/TC150/SC4 N117) but these efforts failed.

There is still no standard for the stem taper. Implant manufacturers continue to use tapers with their own specifications (for example, various 12/14 tapers), which differ in terms of geometry, structure and surface properties \(\text{\textcopyright}\) (Fig. 1). The intervals between the neck lengths (s, m, l and xl) \(\text{\textcopyright}\) (Fig. 2) are also not standardized and can vary from manufacturer to manufacturer by several millimeters.
**Fig. 1:** Different tapers all of which are designated “12/14”

**Fig. 2:** Different neck lengths
Fig. 3a/3b: Characteristics of an implant taper

Fig. 4: Compatibility example: Design difference between two nominally similar 12/14 tapers demonstrated with the fit with a ceramic femoral ball head

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TGP</td>
<td>Taper gage plane</td>
</tr>
<tr>
<td>TGD</td>
<td>Taper gage diameter</td>
</tr>
<tr>
<td>TA</td>
<td>Taper angle</td>
</tr>
<tr>
<td>TL</td>
<td>Taper length</td>
</tr>
<tr>
<td>TCR</td>
<td>Taper chamfer/radius</td>
</tr>
<tr>
<td>TSR</td>
<td>Taper surface roughness</td>
</tr>
<tr>
<td>TS</td>
<td>Taper straightness</td>
</tr>
<tr>
<td>TR</td>
<td>Taper roundness</td>
</tr>
<tr>
<td>TGL</td>
<td>Taper gage length</td>
</tr>
<tr>
<td>TED</td>
<td>Taper end diameter</td>
</tr>
<tr>
<td>TSCD</td>
<td>Taper sharp corner dia.</td>
</tr>
</tbody>
</table>

Cave: Collision of metal taper and ceramic femoral ball head
Features of an implant taper

A taper fixation is made up of a stem taper and a taper in the femoral ball head (drill hole). Each of these tapers has characteristic properties (Fig. 3a/3b) such as taper angle, diameter, straightness and roundness and surface properties, which are essential for a precise matching of the components. For secure taper locking, the fit of the taper fixation between the femoral ball head and the stem taper is very important.

Compatibility

It is vital that surgeons combine only those arthroplasty stems and femoral ball heads that the implant manufacturer has declared to be compatible. The implant manufacturers are responsible for the release of the stem taper / femoral ball head combinations and supply the components to the hospitals. The surgeon must comply with the details regarding approved combinations provided by the implant manufacturer in the instructions for use and other written information.

A survey of the New Zealand Orthopaedic Association showed that 23% of the surgeons had implanted mismatched components within the last 5 years. The most of them occurred in THA. In case of failure to observe compatibility of individual arthroplasty components (Fig. 4), clinical consequences, e.g. with regard to joint geometry with effects on leg length and soft-tissue tension as well as increased metal wear combined with adverse tissue reactions (pseudotumor) and implant failure ahead of time cannot be ruled out.

A meta-analysis indicates that there are insufficient studies of this issue. Information regarding the mechanical behavior of taper locking with inadequately fitting arthroplasty components may be provided by laboratory investigations.
TAKE HOME MESSAGE

• There is no uniform, standardized stem taper.
• Numerous stem tapers are called “Eurotaper 12/14” but this only represents a general size designation and provides neither an indication about compatibility with arthroplasty components from other manufacturers nor information about the precise manufacturer’s specification for a stem taper.
• You must therefore query terms such as 12/14 Eurotaper or Standard Taper 12/14!
• It is essential that you check the compatibility of femoral ball heads and stem tapers!

GLOSSARY

Eurotaper: Not a standard term in hip arthroplasty
Taper: Technical element in the shape of a cone or truncated cone
Taper diameter/conical taper (example 12/14 or 10/12 etc.): Simple characterization of the taper using a rounded and imprecise size definition of the smallest and largest taper diameter with undetermined distance between the two diameter elements
Taper angle: Precise angle of inclination of the cone in its axial direction
Taper diameter: Exact nominal diameter or tested diameter at the defined measurement height on the cone
Femoral ball head minimal definition:
(Example: 32 12/14 M 0 5° 46’ defines a femoral ball head with):
• Ball diameter = 32mm
• Taper diameter:
  start of taper = approx. 12mm
  end of taper = approx. 14mm
• Neck length = M (medium)
• Taper angle = 5° 46’
The implant manufacturer must release the ceramic femoral ball head for use with the particular type of implant.

Straightness: The term describes the straightness of each line on a conical surface in the axial direction.

Roundness: The term describes the roundness of the circumference of any cross-section.

Surface roughness/structure: The term describes the properties and parameters of the surfaces of a technical element.

Acknowledgment
The authors thank Wolfgang Zitzlaff, Tina Mirus and Ines Feistel (Design Dept., CeramTec GmbH) for their energetic and comprehensive support.

References
3 Stokes AP, Rutherford AD. Mismatch of modular prosthetic components in total joint arthroplasty. The New Zealand experience. JBJS BR 2005 87-B:(SUPP I), 32
4 Bisseling P, Tan T Lu Z, Campbell PA, Susante JLC. The absence of a metal-on-metal bearing does not preclude the formation of a destructive pseudotumor in the hip – a case report. Acta Orthop 2013;84(4):437-441

Further references (update)
Hemigou P, Queinnec S, Lachaniette Flouzat CH. One hundred and fifty years of history of the Morse taper:from Stephen A. Morse in 1864 to complications related to modularity in hip arthroplasty. International Orthopaedics (SICOT) 2013;37:2081-2088
Tucker JK, Pickford M, Howard PW, Newell C. Results of “Mixing and Matching” Components from Different Manufacturers in a Total Hip Replacement. Poster 086, AAOS 2014
Willmann G. [Ceramic cups for hip endoprostheses. 4: Never mix and match]. Biomed Tech (Berl) 1996;41:184-186
This document is intended exclusively for experts in the field, i.e., physicians in particular, and is expressly not for the information of laypersons. The information on the products and/or procedures contained in this document is of a general nature and does not represent medical advice or recommendations. Since this information does not constitute any diagnostic or therapeutic statement with regard to any individual medical case, individual examination and advising of the respective patient are absolutely necessary and are not replaced by this document in whole or in part. The information contained in this document was gathered and compiled by medical experts and qualified CeramTec employees to the best of their knowledge. The greatest care was taken to ensure the accuracy and ease of understanding of the information used and presented. CeramTec does not assume any liability, however, for the up-to-dateness, accuracy, completeness or quality of the information and excludes any liability for tangible or intangible losses that may be caused by the use of this information. In the event that this document could be construed as an offer at any time, such offer shall not be binding in any event and shall require subsequent confirmation in writing. BIOLOX® delta and BIOLOX® forte ball heads and BIOLOX® OPTION are registered by CeramTec’s customers. They are not registered/available in all countries.