Comparison of Normal Morphology Assessment Based on WHO 4th and 5th Edition Manual Guidelines

WHO 4th	WHO 5th
Although the morphological variability of the human spermatozoon makes sperm morphology assessment difficult, observations on spermatozoa recovered from the female reproductive tract (especially in postcoital cervical mucus) or from the surface of the zona pellucida have helped to define the appearance of a normal spermatozoon (Fredricsson & Bjork, 1977; Mortimer et al., 1982; Menkveld et al., 1990; Liu & Baker, 1992) .	The variable morphology of human spermatozoa makes assessment difficult, but observations on spermatozoa recovered from the female reproductive tract, especially in postcoital endocervical mucus (Fredricsson & Bjork, 1977; Menkveld et al., 1990) and also from the surface of the zona pellucida (Menkveld et al., 1991; Liu & Baker, 1992a) (see Fig. 2.10), have helped to define the appearance of potentially fertilizing (morphologically normal) spermatozoa.
The heads of stained human spermatozoa are slightly smaller than the heads of living spermatozoa in the original semen, although their shapes are not appreciably different (Katz et al., 1986). Strict criteria should be applied when assessing the morphological normality of the spermatozoon (Menkveld et al., 1990). Using these criteria of classification, there are data to show the predictive value of sperm morphology for fertilization in vitro (Kruger et al., 1986, 1988; Kobayashi et al., 1991; Enginsu et al., 1991; Liu & Baker, 1992; Ombelet et al., 1995).	By the strict application of certain criteria of sperm morphology, relationships between the percentage of normal forms and various fertility endpoints (time-to-pregnancy (TTP), pregnancy rates in-vivo and in-vitro) have been established (Eggert-Kruse et al., 1996; Jouannet et al., 1988; Toner et al., 1995; Coetzee et al., 1998; Menkveld et al., 2001; Van Waart et al., 2001; Garrett et al., 2003; Liu et al., 2003), which may be useful for the prognosis of fertility. Spermatozoa consist of a head, neck, middle piece (midpiece), principal piece and endpiece. As the endpiece is difficult to see with a light microscope, the cell can be considered to comprise a head (and neck) and tail (midpiece and principal piece).
For a spermatozoon to be considered normal, the sperm head, neck, midpiece, and tail must be normal.	For a spermatozoon to be considered normal, both its head and tail must be normal.
This classification scheme requires that all ‘borderline’ forms be considered abnormal (Kruger et al., 1986; Menkveld et al., 1990).	All borderline forms should be considered abnormal.
The head should be oval in shape. Allowing for the slight shrinkage that fixation and staining induce, the length of the head should be 4.0–5.0 µm and the width 2.5-3.5 µm. The length-to-width ratio should be 1.50 to 1.75. These ranges are the 95% confidence limits for Papanicolaou-stained sperm heads (Katz et al., 1986).	The head should be smooth, regularly contoured and generally oval in shape. **Comment 3:** The head dimensions of 77 Papanicolaou-stained spermatozoa (stained by the procedure given in Section 2.14.2 and classified as normal by the criteria given here), measured by a computerized system (coefficient of variation for repeated measurements 2–7%) had the following dimensions: median length 4.1 µm, 95% CI 3.7–4.7; median width 2.8 µm, 95% CI 2.5–3.2; median length-towidth ratio 1.5, 95% CI 1.3–1.8.

There should be a well-defined acrosomal region comprising 40–70% of the head area.	There should be a well-defined acrosomal region comprising 40–70% of the head area (Menkveld et al., 2001).
The midpiece should be slender, less than 1 µm in width, about one and a half times the length of the head, and attached axially to the head.	The midpiece should be slender, regular and about the same length as the sperm head. The major axis of the midpiece should be aligned with the major axis of the sperm head. **Comment 4:** The midpieces of 74 Papanicolaou-stained spermatozoa (stained by the procedure given in Section 2.14.2 and classified as normal by the criteria given here) and measured by the same computerized system had the following dimensions: median length 4.0 µm, 95% CI 3.3–5.2; median width 0.6 µm, 95% CI 0.5–0.7.
Cytoplasmic droplets should be less than half the size of the normal head.	Residual cytoplasm is considered an anomaly only when in excess, i.e. when it exceeds one third of the sperm head size (Mortimer & Menkveld, 2001).
The tail should be straight, uniform, thinner than the midpiece, uncoiled and approximately 45 µm long.	The principal piece should have a uniform calibre along its length, be thinner than the midpiece, and be approximately 45 µm long (about 10 times the headlength). It may be looped back on itself (see Fig. 2.10c), provided there is no sharp angle indicative of a flagellar break. **Comment 5:** Coiled tails (>360°; see Fig. 2.13m) may indicate epididymal dysfunction (Pelfrey et al., 1982).
Since the recommended morphological assessment considers the functional regions of the spermatozoon, it is considered unnecessary routinely to distinguish between all the variations in head size and shape or between the various midpiece and tail defects. However, an additional comment should be made regarding the prevalent defects.	Assessment of sperm morphology is associated with a number of difficulties related to lack of objectivity, variation in interpretation or poor performance in external quality-control assessments (see Section 7.13.2). The method recommended here is a simple normal/abnormal classification, with optional tallying of the location of abnormalities in abnormal spermatozoa.