SCORING GUIDELINES FOR BONE AGE ESTIMATION

CONTENTS

GUIDELINES FOR PUBIC SYMPHYSIS PHASES:

PHASE 1: A DISTINCT RIDGE AND FURROW PATTERN EXTENDS FROM THE PUBIC TUBERCLE TO THE INFERIOR RAMUS. THE RIDGES AND FURROWS ARE DEEP, WELL-DEFINED, AND SHOW NO SIGNS OF WEAR. THERE IS NO DORSAL LIPPING. THE BONE QUALITY IS GOOD—FIRM, DENSE, HEAVY, AND SMOOTH ON BOTH THE VENTRAL AND DORSAL SURFACES. NO RIM FORMATION IS PRESENT, AND THE DORSAL PLATEAU HAS NOT YET DEVELOPED. THE RIDGES AND FURROWS CONTINUE TO THE DORSAL EDGE.

PHASE 2: THE RIM IS BEGINNING TO FORM, MAINLY THROUGH THE FLATTENING OF THE DORSAL RIDGES, WITH SMALL OSSIFIC NODULES APPEARING ALONG THE VENTRAL BORDER. RIDGES AND FURROWS ARE STILL VISIBLE BUT MAY LOOK SLIGHTLY WORN OR FLATTENED, ESPECIALLY ON THE DORSAL SURFACE, WHERE THE FURROWS ARE BECOMING SHALLOWER. THE UPPER AND LOWER RIM EDGES HAVE NOT YET FULLY FORMED, AND THERE IS NO DORSAL LIPPING. BONE QUALITY REMAINS VERY GOOD—FIRM, DENSE, HEAVY, AND SMOOTH ON BOTH THE VENTRAL AND DORSAL SURFACES, WITH MINIMAL POROSITY. THE PUBIC TUBERCLE MAY APPEAR SLIGHTLY DETACHED FROM THE FACE.

PHASE 3: THE LOWER RIM IS FULLY FORMED ON THE DORSAL SIDE, EXTENDING UP THE VENTRAL SURFACE BUT STOPPING MIDWAY, LEAVING A MODERATE TO LARGE GAP BETWEEN THE UPPER AND LOWER EXTREMITIES. THIS WIDENED "V" SHAPE IS LONGER ON THE DORSAL SIDE THAN THE VENTRAL. SOME RIDGES AND SHALLOW FURROWS ARE STILL PRESENT BUT APPEAR WORN DOWN. IN SOME CASES, THE SURFACE IS BECOMING SLIGHTLY POROUS. THE RIM IS DEVELOPING BOTH ON THE DORSAL ASPECT AND ALONG THE UPPER AND LOWER EXTREMITIES. OCCASIONALLY, THERE IS A ROUNDED BUILDUP OF BONE IN THE GAP ABOVE THE ENLARGED "V." BONE QUALITY REMAINS GOOD—FIRM, DENSE, HEAVY, AND MOSTLY NON-POROUS. THE DORSAL SURFACE IS SMOOTH, WITH SMALL BONY PROJECTIONS NEAR THE MEDIAL ASPECT OF THE OBTURATOR FORAMEN. **VARIANT:** IN SOME CASES (MALES ONLY), A DEEP LINE OR EPIPHYSEAL STRUCTURE IS VISIBLE ON THE VENTRAL ASPECT, RUNNING PARALLEL AND ADJACENT TO THE FACE.

PHASE 4: BY THIS STAGE, THE RIM IS MOSTLY COMPLETE, THOUGH SMALL GAPS MAY STILL APPEAR ON THE SUPERIOR AND VENTRAL ASPECTS. THE FACE REMAINS FLAT RATHER THAN DEPRESSED, AND REMNANTS OF RIDGES AND FURROWS MAY STILL BE VISIBLE, PARTICULARLY ON THE LOWER HALF. THE BONE QUALITY IS GOOD, BUT THE FACE IS BEGINNING TO SHOW INCREASED POROSITY. BOTH THE DORSAL AND VENTRAL SURFACES OF THE BODY ARE BECOMING ROUGH AND COARSE. A SLIGHT DEGREE OF DORSAL LIPPING IS PRESENT, AND IN FEMALES WITH PARTURITION PITS, THIS LIPPING MAY BE MORE PRONOUNCED. THE VENTRAL ARC, WHEN PRESENT IN FEMALES, CAN BE LARGE AND INTRICATE.

PHASE 5: THE FACE IS BECOMING MORE POROUS AND SLIGHTLY DEPRESSED BUT RETAINS AN OVERALL OVAL SHAPE, AVOIDING IRREGULAR OR ERRATIC CONTOURS. AT THIS STAGE, THE RIM IS FULLY DEVELOPED AND GENERALLY MAINTAINS A REGULAR FORM. RIDGES AND FURROWS ARE NO LONGER PRESENT. SOME DETERIORATION MAY OCCUR ALONG THE VENTRAL BORDER, GIVING IT AN IRREGULAR APPEARANCE RATHER THAN A SOLID, ROUNDED FORM. THE VENTRAL SURFACE IS ROUGH AND IRREGULAR, SOMETIMES EXHIBITING SMALL BONY GROWTHS. THE DORSAL SURFACE IS SIMILARLY COARSE AND UNEVEN. PROJECTIONS CAN BE FOUND NEAR THE MEDIAL ASPECT OF THE OBTURATOR FORAMEN. BONE QUALITY IS MODERATE TO FAIR, WITH REDUCED DENSITY AND A LESS SMOOTH TEXTURE. THE BONE IS MODERATELY LIGHTWEIGHT. IN FEMALES, THE VENTRAL ARC REMAINS PROMINENT.

PHASE 6: THE FACE IS LOSING ITS DISTINCT OVAL SHAPE, BECOMING MORE IRREGULAR. ALTHOUGH THE RIM REMAINS INTACT, IT IS BEGINNING TO ERODE, ESPECIALLY ALONG THE VENTRAL BORDER. BOTH THE RIM AND THE FACE EXHIBIT INCREASED POROSITY AND MACROPOROSITY. BONE QUALITY IS FAIR, WITH A LIGHTER STRUCTURE AND GREATER POROSITY, DESPITE THE PRESENCE OF BONY BUILDUP ON THE VENTRAL BODY SURFACE. THE RIM CONTINUES TO DEGRADE, WHILE THE DORSAL SURFACE REMAINS ROUGH AND COARSE. RIDGES AND FURROWS ARE ABSENT, AND DORSAL LIPPING IS NOW VISIBLE. PROJECTIONS ARE PRESENT AT THE MEDIAL ASPECT OF THE OBTURATOR FORAMEN. BONE WEIGHT IS A KEY DISTINGUISHING FACTOR BETWEEN PHASES 6 AND 7.

PHASE 7: AT THIS STAGE, BOTH THE FACE AND RIM ARE HIGHLY IRREGULAR IN SHAPE AND ARE DETERIORATING SIGNIFICANTLY. WHILE THE RIM REMAINS INTACT, IT IS ERODING AND BREAKING DOWN, PARTICULARLY ALONG THE VENTRAL BORDER. RIDGES AND FURROWS ARE NO LONGER PRESENT. THE FACE IS POROUS, AND EXHIBITS PRONOUNCED MACROPOROSITY. DORSAL LIPPING IS SEVERE. BONE QUALITY IS POOR, WITH THE STRUCTURE BECOMING EXTREMELY LIGHT AND BRITTLE. THE DORSAL AND VENTRAL SURFACES ARE ROUGH AND ELABORATE. PROJECTIONS CONTINUE TO BE PRESENT AT THE MEDIAL WALL OF THE OBTURATOR FORAMEN. THE PUBIC TUBERCLE IS HIGHLY DEVELOPED AND PROLIFERATIVE. BONE WEIGHT IS A CRITICAL FACTOR IN DISTINGUISHING PHASE 7 FROM PHASE 6. **VARIANT FOR PHASE 7:** THE RIM REMAINS MOSTLY INTACT, EXCEPT FOR A LYTIC OR SCLEROTIC-LOOKING GAP AT THE SUPERIOR VENTRAL MARGIN, WHICH MAY EXTEND TOWARD THE PUBIC TUBERCLE OR BENEATH THE VENTRAL RIM. THIS SHOULD NOT BE MISTAKEN FOR A NATURAL HIATUS.

(Hartnett, 2010, Table A1)

GUIDELINES FOR STERNAL EDGES OF THE FOURTH RIBS PHASES:

PHASE 1: THE PIT CONTAINS BILLOWS AND IS VISIBLY SHALLOW AND FLAT WITH A U-SHAPED CROSS-SECTION. THE BONE IS OF GOOD QUALITY, SMOOTH, DENSE AND NOTICIBLY SOLID. THE RIM OF THE PUBIC SYMPHYSIS MAY SHOW THE EMERGENCE OF SCALLOPING BUT HAVE THICK WALLS.

PHASE 2: THE PIT HAS AN INDENTATION AND A V-SHAPED CROSS-SECTION. INSIDE, THE PIT IS SMOOTH WITH LITTLE TO NO POROSITY. THE BONE IS OF GOOD QUALITY, SMOOTH, DENSE, AND NOTICIBLY SOLID. THE RIM IS REGULAR WITH SOME DEGREE OF SCALPING AND HAS NO FLARE TO THE EDGES. THE RIB EDGES ALIGN PARALLEL TO EACH OTHER. IN FEMALES, THE CENTRAL ARC (LOCATED ON THE ANTERIOR AND POSTERIOR WALLS AS A SEMICIRCULAR CURVE) IS VISIBLE.

PHASE 3: THE PIT HAS NO PROJECTIONS AND A V-SHAPED CROSS-SECTION. INSIDE OF THE PIT THERE IS NOTICIBLE POROSITY. THE RIB EDGES ARE ROUNDED, BUT SHARP AND HAVE A SLIGHT FLARE. THE RIB EDGES ARE BECOMINING IRREGULAR AND MAY SHOW SOME REMNANTS OF WORN-DOWN SCALLOPS. THE BONE IS OF GOOD QUALITY, SMOOTH, AND SOLID. IN FEMALES, THERE IS A BUILD-UP OF BONY PLAQUE EITHER ALONG THE BOTTOM OF THE PIT OR ALONG ITS INTERIOR THAT CREATES THE APPEARANCE OF A TWO-LAYER RIM. THE CENTRAL ARC MAY BE IRREGULAR.

PHASE 4: THE PIT IS DEEP AND U-SHAPED WITH POROSITY IN THE INTERIOR. ITS EDGES HAVE NO LONG BONY PROJECTIONS AND EXPAND OUTWARDS. THE RIB EDGES ARE NOT SCALLOPED, BUT THEY ARE IRREGULAR AND THIN, YET STILL FIRM. THE BONE QUALITY IS GOOD, BUT IT DOES NOT FEEL DENSE OR HEAVY. IN MALES, THERE ARE TWO DISTINCT DEPRESSIONS VISIBLE INSIDE OF THE PIT. IN FEMALES, THE CENTRAL ARC MAY BE PRESENT AND IRREGULAR, BUT ITS PROMINENCE HAS BEEN DECREASED BY THE DEVELOPMENT OF THE SUPERIOR AND INFERIOR EDGES OF THE RIM.

PHASE 5: THE PIT IS DEEP, U-SHAPED, AND CONTAINS POROSITY WITHIN. THE RIB EDGES ARE IRREGULAR, FLARED, SHARP, AND THIN WITH FREQUENT SMALL BONY PROJECTIONS. THE BONE QUALITY IS FAIR. THE BONE FEELS LIGHTER THAN IT LOOKS AND IS COARSE TO THE TOUCH.

PHASE 6: THE PIT IS DEEP, U-SHAPED, AND CONTAINS POROSITY WITHIN. THE RIB EDGES ARE IRREGULAR, FLARED, SHARP, AND THIN WITH FREQUENT SMALL BONY PROJECTIONS. THE BONE QUALITY IS FAIR TO POOR. THE BONE FEELS LIGHTER THAN IT LOOKS AND IS COARSE TO THE TOUCH.

PHASE 7: THE PIT IS DEEP, U-SHAPED, AND MAY CONTAIN LONG BONY GROWTHS WITHIN. THE BONE IS OF VERY POOR QUALITY AND POSSIBLY TRANSLUCENT. IT IS VERY LIGHT WITH A PAPER-LIKE FEEL AND FEELS COARSE AND BRITTLE TO THE TOUCH. THE RIM IS VERY IRREGULAR WITH LONG BONY PROTRUSIONS. MUCH OF THE CARTILAGE MAY BE OSSIFIED AND WINDOW FORMATIONS MAY OCCUR. IN FEMALES, MUCH OF THE CARTILAGE INSIDE OF THE PIT MAY BE OSSIFIED INTO A BONY PROTRUSION EXTENDING MORE THAN A CM IN LENGTH. **VARIANT:** IN MALES, THE CARTILAGE MAY HAVE COMPLETELY OR ALMOST COMPLETELY OSSIFIED. THIS OSSIFICATION TENDS TO BE A SOLID EXTENSION OF BONE RATHER THAN A THIN PROJECTION. IN THESE CASES, ALL OF THE BONE IS OF VERY GOOD QUALITY, INCLUDING THE OSSIFICATION. THE BONE IS DENSE, HEAVY, AND SMOOTH. IN THIS SITUATION, THE BONE QUALITY SHOULD BE THE DETERMINING FACTOR. IT IS POSSIBLE THAT OTHER FACTORS, SUCH AS DISEASE, TRAUMA, OR SUBSTANCE ABUSE, CAUSED PREMATURE OSSIFICATION OF THE CARTILAGE.

(Hartnett, 2010, Appendix A)

GUIDELINES FOR AURICULAR SURFACE PHASES:

Phase 1: Billowing with possible striae; mostly fine granularity with some coarse granularity possible.

Phase 2: Striae; coarse granularity with residual fine granularity; retroauricular activity possible.

Phase 3: Decreased striae with transverse organization; coarse granularity becoming, replaced by densification; retroauricular activity present; beginnings of apical change.

Phase 4: Remnants of transverse organization; Densification starting to replace coarse granularity; retroauricular activity present; apical change; macroporosity is present.

Phase 5: Surface is irregular with a largely dense texture; moderate retroauricular activity; moderate apical change; macroporosity is present.

Phase 6: Irregular surface; densification accompanied by subchondral destruction; severe retroauricular activity; severe apical change; macroporosity is present.

Osborne, Simmons, & Nawrocki, 2004, Table 9

GUIDELINES FOR THIRD MOLAR PHASES:

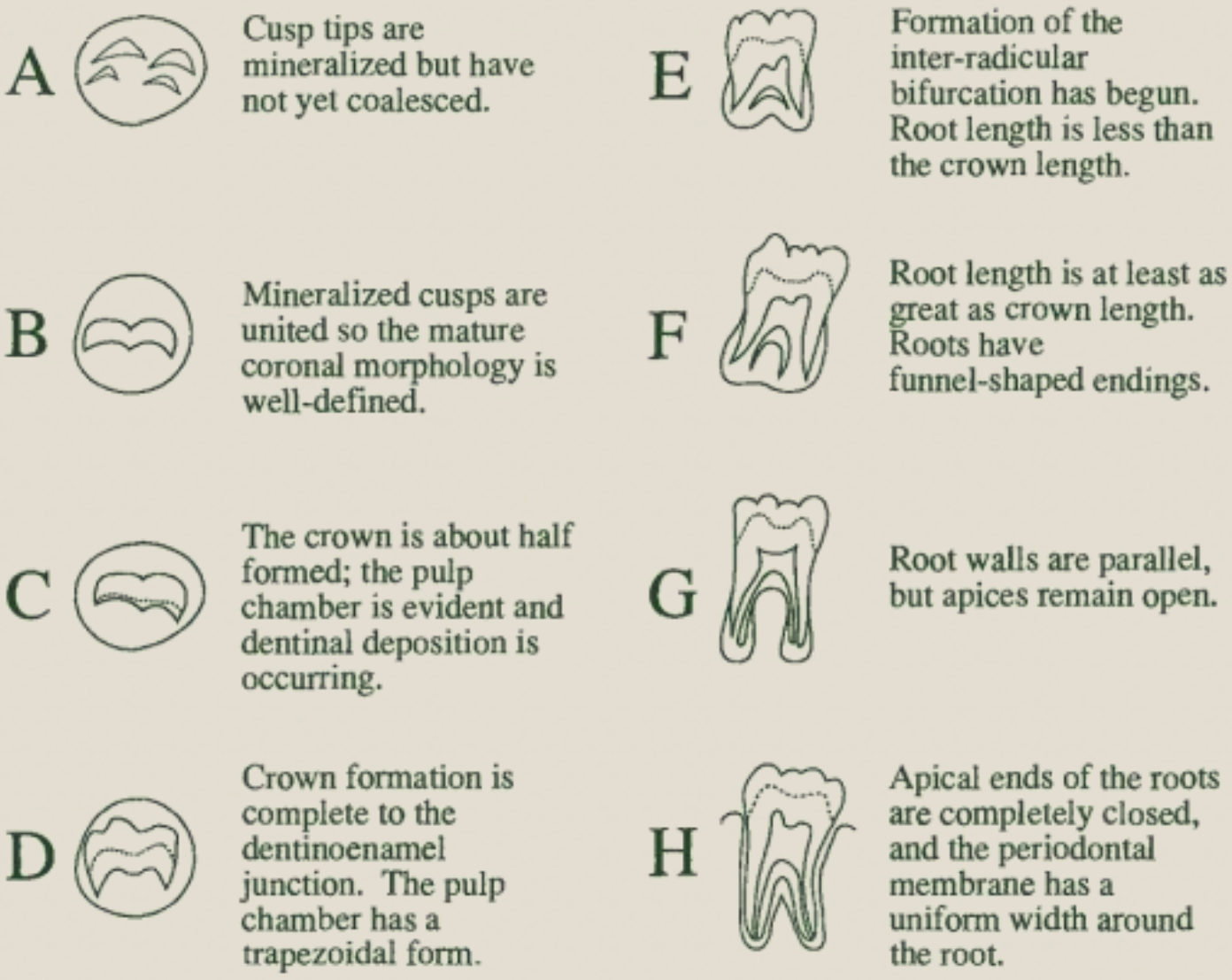

FIG. 1—*Schematic drawings and definitions of the eight stages of crown and root formation used to score third molar development (modified from Demirjian et al. [8]). Grades A and B did not occur in the age interval examined (14.1 to 24.9 yrs), and grade C occurred in less than 1% of the sample and was omitted from analysis.*

(Mincer, Harris, & Berryman, 1993)

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