Classifications of glenoid dysplasia, glenoid bone loss and glenoid loosening: a review of the literature

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ORIGINAL ARTICLE

Classifications of glenoid dysplasia, glenoid bone loss and glenoid loosening: a review of the literature

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Abstract So far, glenoid implantation still remains a challenge and is technically demanding even for an experienced shoulder surgeon. Each shoulder pathology has its own evolution. In primary glenohumeral osteoarthritis, glenoid involvement and proper morphology vary considerably. Erosion is more posterior and inferior. In rheumatoid arthritis, glenoid erosion is more medial with a very weak and soft bone. In eccentric arthritis, glenoid erosion is most of the time superior. Glenoid component loosening has been recognized as one of the common indications for revision surgery after total shoulder arthroplasty. Scapular notching is specific to the reverse shoulder arthroplasty. Moreover, there is concern about the high frequency of glenoid components that demonstrate radiographic periprosthetic lucencies. There is little information available to guide clinical decision making regarding glenoid surgery. Placement or replacement with a standard glenoid component is usually possible. In some instances, bone graft reconstruction or the use of augmented or custom components can be an option. The purpose of this study is to evaluate the main glenoid erosion classifications.

Keywords Classification · Glenoid · Dysplasia · Bone loss · Loosening · Glenoid component

Introduction

In primary glenohumeral osteoarthritis, glenoid involvement and proper morphology vary considerably. Neer [1, 2] stated that there is a frequent posterior erosion of the glenoid in this condition and a posterior subluxation of the humeral head. Friedman [3] and Mullaji [4] reported an excessive retroversion of the glenoid. In a series of 1,150 scapular bone specimens, Edelson [5] assumed that inferior glenoid deformity in addition to posterior glenoid wear occurred in patients with osteoarthritis.

In total shoulder arthroplasty, it is important to detect and to correct decentering of the humeral head to avoid early polyethylene wear as well as loosening of the glenoid component caused by the so-called rocking-horse phenomena introduced by Matsen [6] which can induce glenoid component loosening.

We propose a review of the literature of the main classifications of the glenoid dysplasia, glenoid bone loss and glenoid component loosening.

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Glenoid dysplasia

Classification of horizontal glenoid morphology in primary glenohumeral osteoarthritis (GHOA) according to Walch [7] (Fig. 1)

The authors classified into three types the precise morphology of the glenoid in primary GHOA using computed tomography (CT) scans of 113 osteoarthritic shoulders to clarify the cause, evolution and treatment for primary GHOA.

Intra-observer reproducibility and inter-observer reliability were good.

Type A (59 %) The humeral head was centered, and the resultant strengths were equally distributed against the surface of the glenoid. Glenoid retroversion averaged 11.5°, standard deviation [SD] 8.8°. The erosion may be

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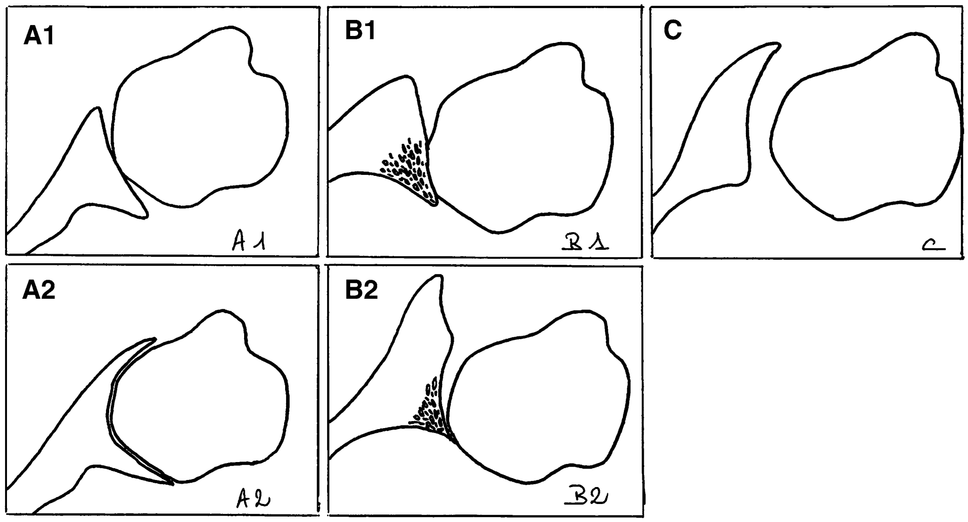


Fig. 1 Three types of glenoid morphology described by Gilles Walch [7]

minor (type Al, 43 %) or major (type A2, 16 %) marked by central erosion that led to a centered glenoid cupula. In advanced cases, the humeral head protruded into the glenoid cavity. Patient age increased with the amount of the glenoid central erosion.

Type B (32 %) The humeral head was subluxated posteriorly (index of subluxation of the humeral head averaged 59 %), and the distributed loads were asymmetric. The CT scan revealed numerous anatomic changes, more pronounced on the posterior margin of the glenoid. The retroversion averaged 18° (SD 7.2°). Two subgroups were identified: B1 (17 %) showed narrowing of the posterior joint space, subchondral sclerosis and osteophytes. B2 (15 %) demonstrated a posterior cupula that gave an unusual but typical biconcave aspect of the glenoid. Again there is a significant difference between the mean ages (63 year old in B1 group, 71 year old in B2 group). The glenoid retroversion increased from B1 (14.9°) to type 2 (23.4°), but the value of the retroversion does not explain the biconcavity of the glenoid.

Type C (9 %) This type of glenoid morphology was defined by a glenoid retroversion of more than 25°, regardless of the erosion. The retroversion was of dysplastic origin, clearly congenital, and the humeral head was well centered or slightly subluxated posteriorly (index of subluxation ranged from 35 to 75 %, with an average value of 55 %). The average retroversion was 35.7° (SD 5.9°). Average age was 61.4 year old.

Classification of vertical glenoid morphology in primary glenohumeral osteoarthritis (GHOA) according to Habermeyer [8] (Fig. 2)

In osteoarthritis of the shoulder, the tilt of the glenoid surface undergoes an eccentric deformation not only in the antero-posterior but also in the supero-inferior direction. Standardized radiographs of 100 consecutive patients with primary osteoarthritis of the shoulder and 100 otherwise healthy patients with shoulder pain (the control group) were included. The authors defined four different types of inclination deformity of the glenoid in the true antero-posterior view due to a vertical line perpendicular to the inferior border of the X-ray film along the lateral base of the coracoid (coracoid baseline) and along the superior and inferior glenoid rim (glenoid line).

A significant difference ($p < 0.0001$) in the distribution of glenoid types between the two patient groups was observed. Four different types of glenoid are described:

Type 0 Normal glenoid. A line at the base of the coracoid process and a line at the glenoid rim run parallel.
Type 1 Both lines intersect below the inferior glenoid rim.
Type 2 The line at the base of the coracoid process and the glenoid line intersect between the inferior glenoid rim and the center of the glenoid.
Type 3 The lines intersect above the base of the coracoid process.

Significantly, more patients with osteoarthritis were found to have a glenoid type 2 or type 3, and the mean angle of inclination was −12.6° (range −32°–7°). In the control group, the mean inclination angle was −2.2° (range −12° to −7°).

Forty-seven patients with osteoarthritis showed combined posterior and inferior glenoid wear. The authors found no correlation between the type of inclination and the type of glenoid morphology. In osteoarthritis, eccentric inferior glenoid wear is frequent and independent from retroversion deformity of the glenoid. Therefore, measurement of the inclination angle does not describe glenoid wear in the coronal plane sufficiently. Normalization of

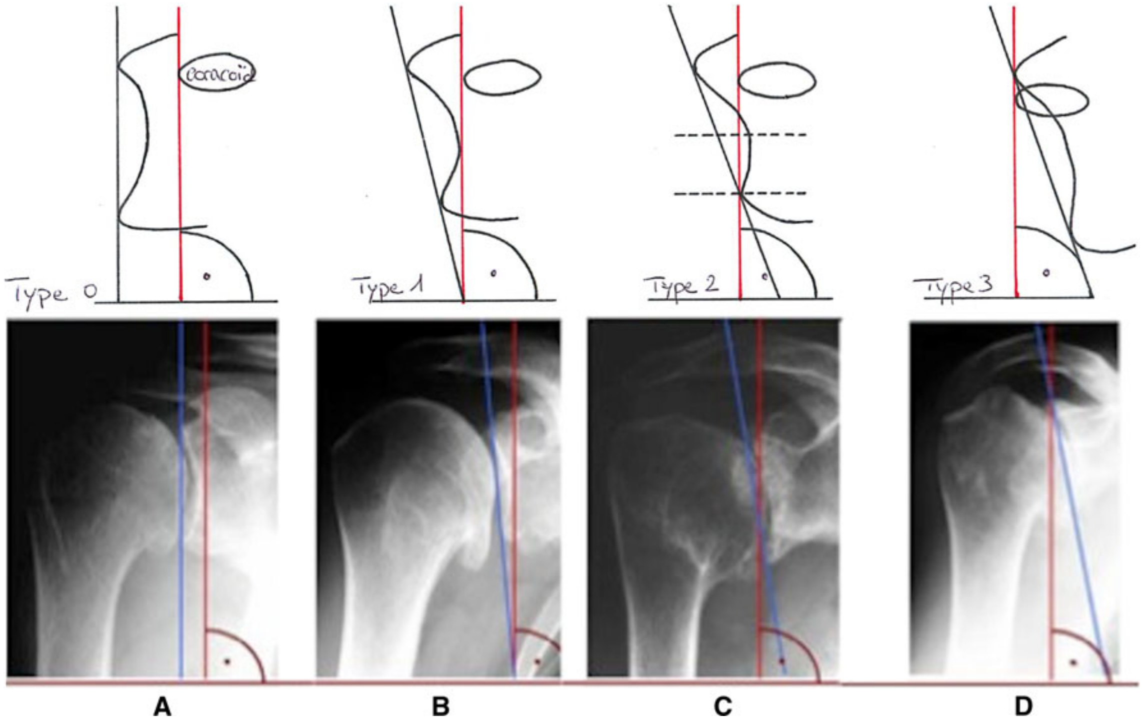


Fig. 2 Four different types of Habermeyer glenoid (*vertical*) inclination [8]

glenoid version in both transverse and coronal planes may reduce eccentric loading of the prosthetic glenoid, which has been associated with loosening.

Classification of glenoid erosion in glenohumeral osteoarthritis with massive rupture of the cuff according to Sirveaux [9] (Fig. 3)

The authors reviewed 80 shoulders (77 patients) at a mean follow-up of 44 months after insertion of a Grammont inverted shoulder prosthesis. Based upon the pre-operative radiological appearance, four types of glenoid erosion were defined:

Type E0 The head of the humerus migrated upwards without erosion of the glenoid.
Type E1 There is a concentric erosion of the glenoid.
Type E2 There is an erosion of the superior part of the glenoid.
Type E3 The erosion extended to the inferior part of the glenoid.

Loss of bone from the superior part of the glenoid leads the surgeon to position the base plate on the top, which increases the risk of impingement. It is important to be careful in such cases, especially for glenoid types E2 or E3. It is better to position the base plate on the lower part of the glenoid, with a slight tilt.

Classification of glenoid wears in rheumatoid arthritis according to Lévigne and Franceshi [10] (Fig. 4)

Stage 1 The subchondral bone is intact or minimally deformed.
Stage 2 The wear reaches the foot of the coracoid.
Stage 3 The wear goes beyond the foot of the coracoid.

Glenoid bone loss in case of revision for total shoulder arthroplasty or reverse shoulder arthroplasty

Classification of glenoid bone loss in reverse shoulder arthoplasty (scapular notch) according to Sirveaux [9] (Fig. 5)

The scapular notch, which is a defect of the bone in the inferior part of the glenoid component, was noted and was classified according to the size of the defect as seen on the radiograph.

Grade 1 A defect, which is confined to the pillar.
Grade 2 The defect is in contact with the lower screw.
Grade 3 The defect is over the lower screw.
Grade 4 The defect extends under the base plate.

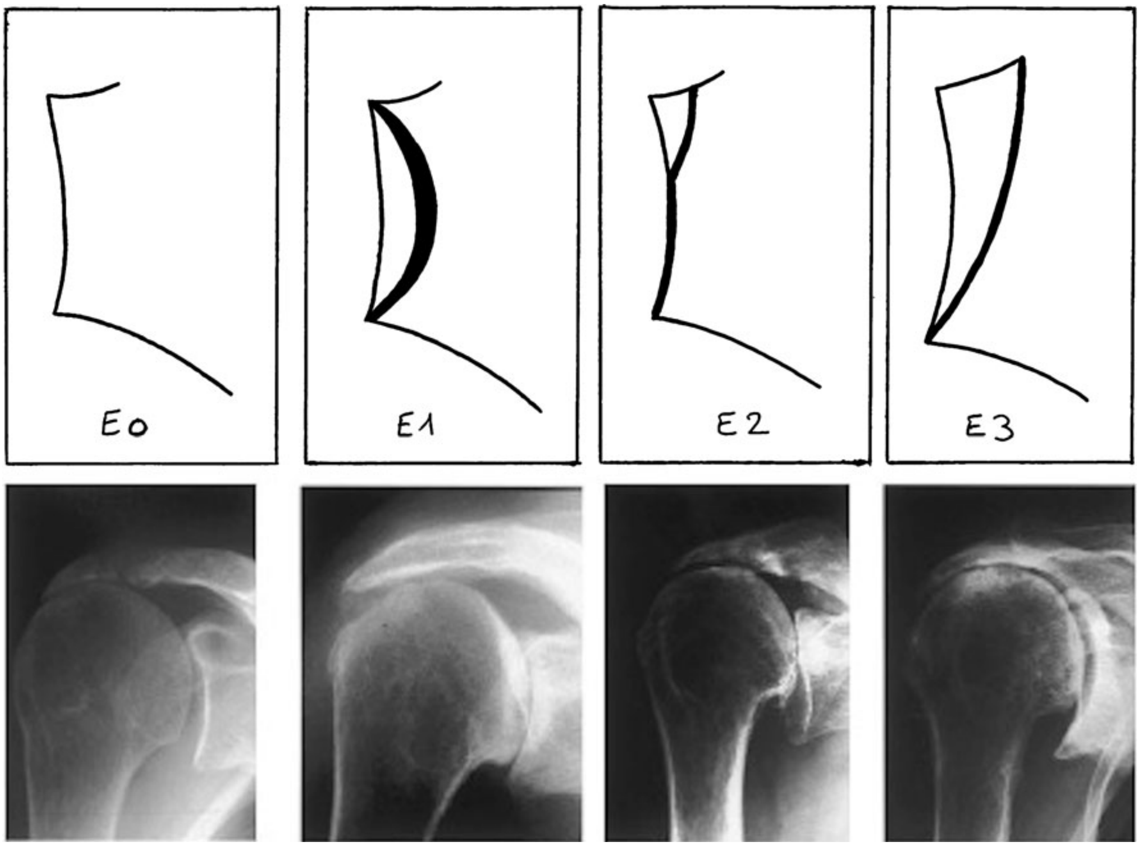
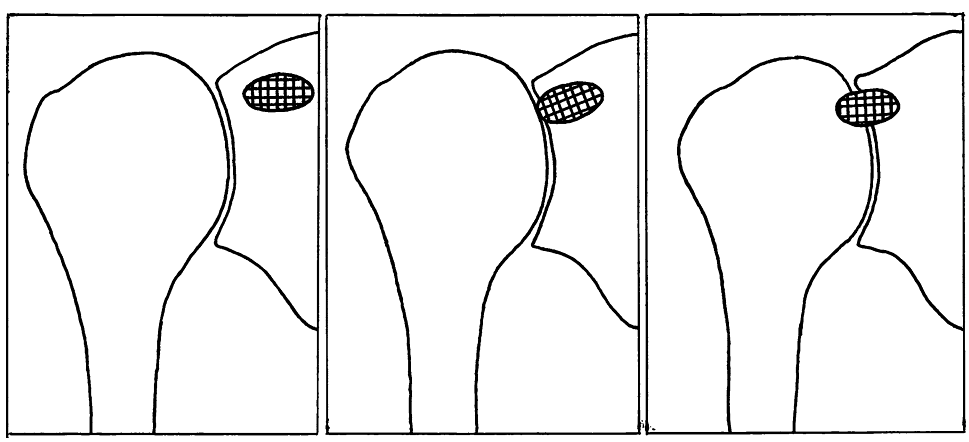


Fig. 3 The four types of glenoid erosion in eccentric osteoarthritis according to Sirveaux [9]

Fig. 4 The three stages of glenoid erosion in rheumatoid arthritis according to Lévigne and Franceschi [10]



Classification of glenoid bone deficiencies after glenoid component removal according to Antuna [11] (Fig. 6)

Forty-eight shoulders that underwent glenoid component revision surgery were reviewed at a mean of 4.9 years (range 2–12 years). The indications for surgery were glenoid component loosening in 29 shoulders, glenoid implant failure in 14 shoulders and glenoid component malposition or wear leading to instability in 5 shoulders. Thirty shoulders underwent implantation of a new glenoid component, and 18 underwent removal of the component and bone grafting for bone deficiencies.

Glenoid bone loss is categorized intra-operatively on the basis of location and severity. Based on the location, the

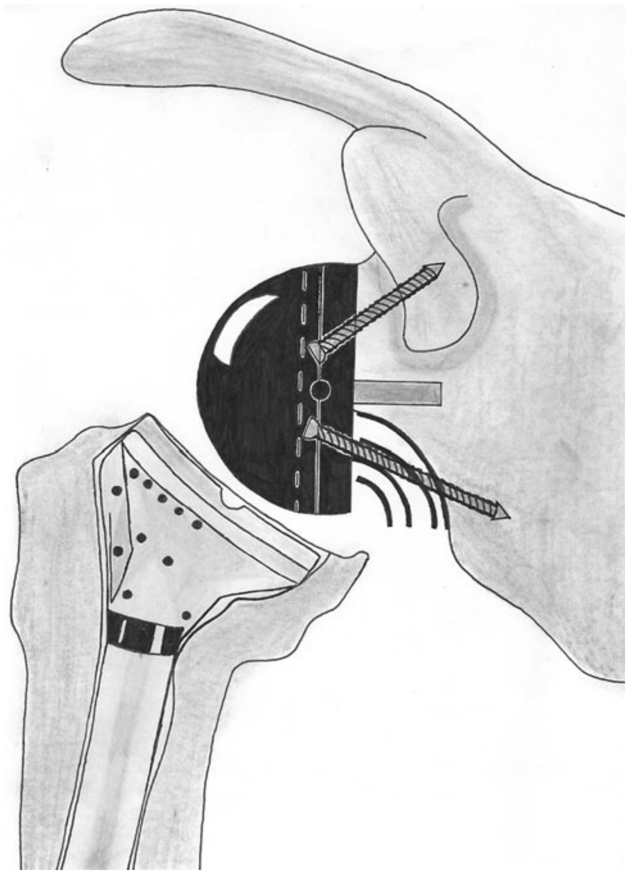


Fig. 5 The four grades of scapular notching according to Sirveaux [9]

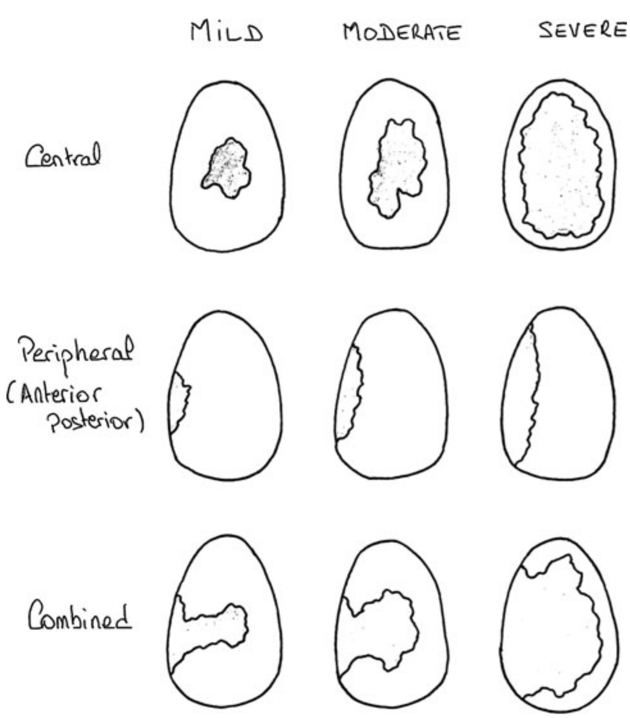


Fig. 6 Classification of glenoid bone deficiencies after glenoid component removal according to Antuna [11]

defects are categorized as central, peripheral or combined. Based on the severity, deficiencies are categorized as mild (less than one-third of the glenoid rim or surface), moderate (between one-third and two-thirds) or severe (more than two-thirds).

Classification of glenoid bone deficiencies after glenoid component removal according to Sauzières [12] (Fig. 7)

Stage A Central loss respecting cortical bone. The glenoid can be grafted with cancellous bone and by protecting the grafts with a cortico-cancellous bone covering.
Stage B Bone defect on the anterior wall of less than one-third of the length of the trumpet-shaped glenoid. The MB allows the use of a screwed cortico-cancellous bone graft.
Stage C Same thing as *stage B* but on the posterior wall.
Stage D Bone loss affecting both walls for at least one-third of the bony trumpet-shaped glenoid. This needs a special revision implant with a longer central peg.
Stage E Bone defect for more than one-third. This is not an indication for a total shoulder arthroplasty.

Classification of glenoid component loosening after shoulder arthroplasty

Classification and radiographic assessment of radiolucent lines of the glenoid component according to Sperling [13] (Fig. 8)

Sixty-two primary ingrowth total shoulder arthroplasties performed between 1989 and 1992 and with a minimum radiographic and clinical follow-up of 2 years or until the time of revision surgery (mean 4.6 years) were reviewed.

Components are divided into radiographic zones for measurements of periprosthetic lucency; the glenoid has five zones. The lines are evaluated according to their presence or absence, location and thickness. The maximum thickness of the line is measured within 0.5 mm.

To combine data on both the distribution and the thickness of periprosthetic lucency and change in component position, some criteria were used to determine whether a component was radiographically "at risk" for clinical component loosening. A glenoid component was "at risk" when a complete lucent line was present, some part of it being 1.5 mm or greater in width, or when at least 2 of 3 independent observers identified migration or tilt of the component.

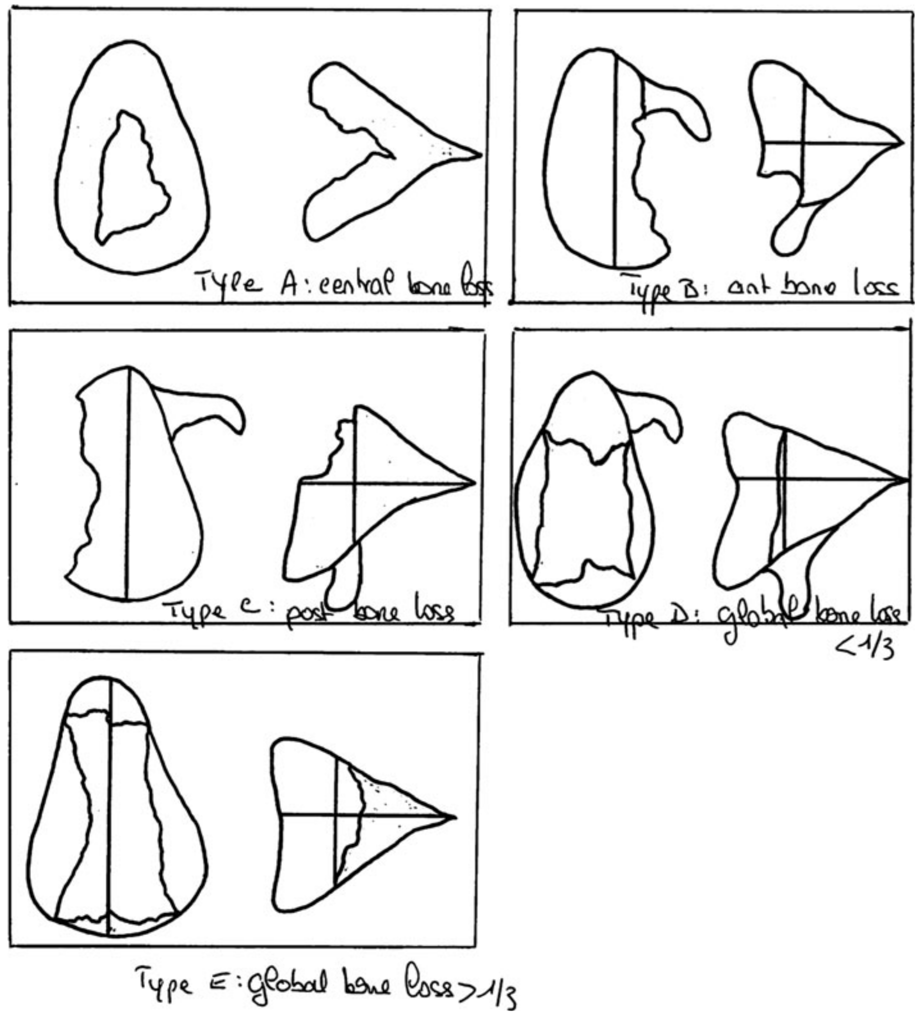


Fig. 7 Classification of glenoid bone loss after glenoid component removal according to Sauzières [12]

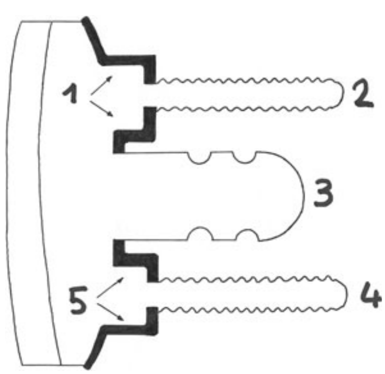


Fig. 8 Classification of glenoid radiolucent lines according to Sperling [13]

Classification and radiographic assessment of radiolucent lines of the cemented glenoid component according to Molé [14] (Fig. 9)

The position of the radiolucent lines is established using six zones from the upper to periphery of the keel and the middle part of the tray. Their thickness is measured in three grades: grade 1 (<1 mm), grade 2 (between 1 and 2 mm), grade 3 (>2 mm).

The authors also calculated the radiolucent line score (RLL score) using the six zones and three grades. RLL score is the sum of each zone involved multiplied by its grade, giving a maximum of 18. The glenoid component is arbitrarily considered as being loose if the score is greater than 12.

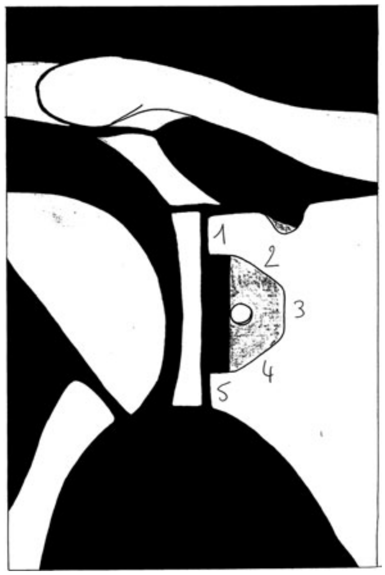


Fig. 9 Classification of radiolucent lines in glenoid component loosening according to Molé [14]

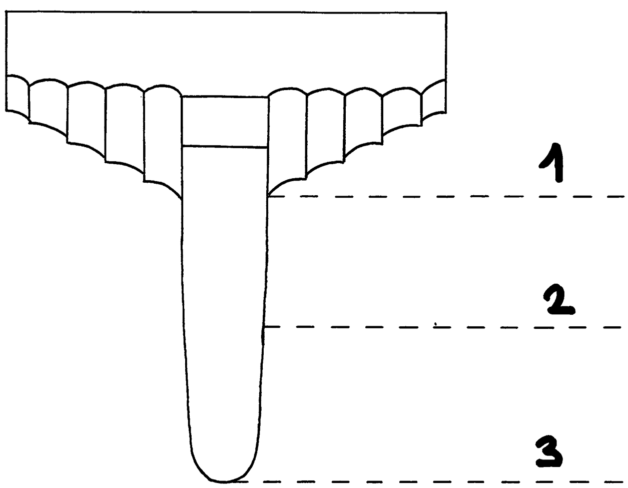


Fig. 10 Three classifications of radiolucent zones described by Wilde [16]

The radiolucent lines are considered to be progressive when the RLL score increases with time.

Classification and radiographic assessment of radiolucent lines of the glenoid component according to Franklin [15]

Seven cases of total shoulder arthroplasty exhibiting major glenoid radiolucent lines or actual translation of the glenoid component were evaluated to identify factors associated with glenoid loosening.

Seven classes of radiolucencies are described.

Class 0 No lucency.
Class 1 Lucency at the superior and/or inferior flange only.
Class 2 Incomplete lucency at the keel.
Class 3 Complete lucency of up to 2 mm around the component.
Class 4 Complete lucency greater than 2 mm around the component.
Class 5a Component translated (tipped or shifted).
Class 5b Component dislocated from the bone.

Classification and radiographic assessment of radiolucent lines of the cemented glenoid component according to Wilde [16] (Fig. 10)

An evaluation is made of the thickness of the radiolucent zone at the bone–cement interface around the glenoid component. The authors define three zones:

Zone 1 The interface between the subchondral bone of the glenoid and the collar of the prosthesis.
Zone 2 The interface between the subchondral bone of the glenoid and the lateral part of the keel.
Zone 3 The interface between the subchondral bone of the glenoid and the medial part of the keel.

A radiolucent line in zone 1 may be normal, as the hard subchondral bone does not permit inter-digitations with the cement.

Classification and radiographic assessment of radiolucent lines of the cemented glenoid component according to Lazarus [17], (Figs. 11, 12)

Grading scale for radiolucencies about pegged components grade

Grade 0 No radiolucency.
Grade 1 Incomplete radiolucency around 1 or 2 pegs.
Grade 2 Complete radiolucency (<2 mm wide) around 1 peg only, with or without incomplete radiolucency around one other peg.
Grade 3 Complete radiolucency (<2 mm wide) around 2 or more pegs.
Grade 4 Complete radiolucency (>2 mm wide) around 2 or more pegs.
Grade 5 Gross loosening.

Grading scale for completeness of glenoid component seating grade

Although the figure shows a keeled component according to Barwood [18], the system can be used for pegged

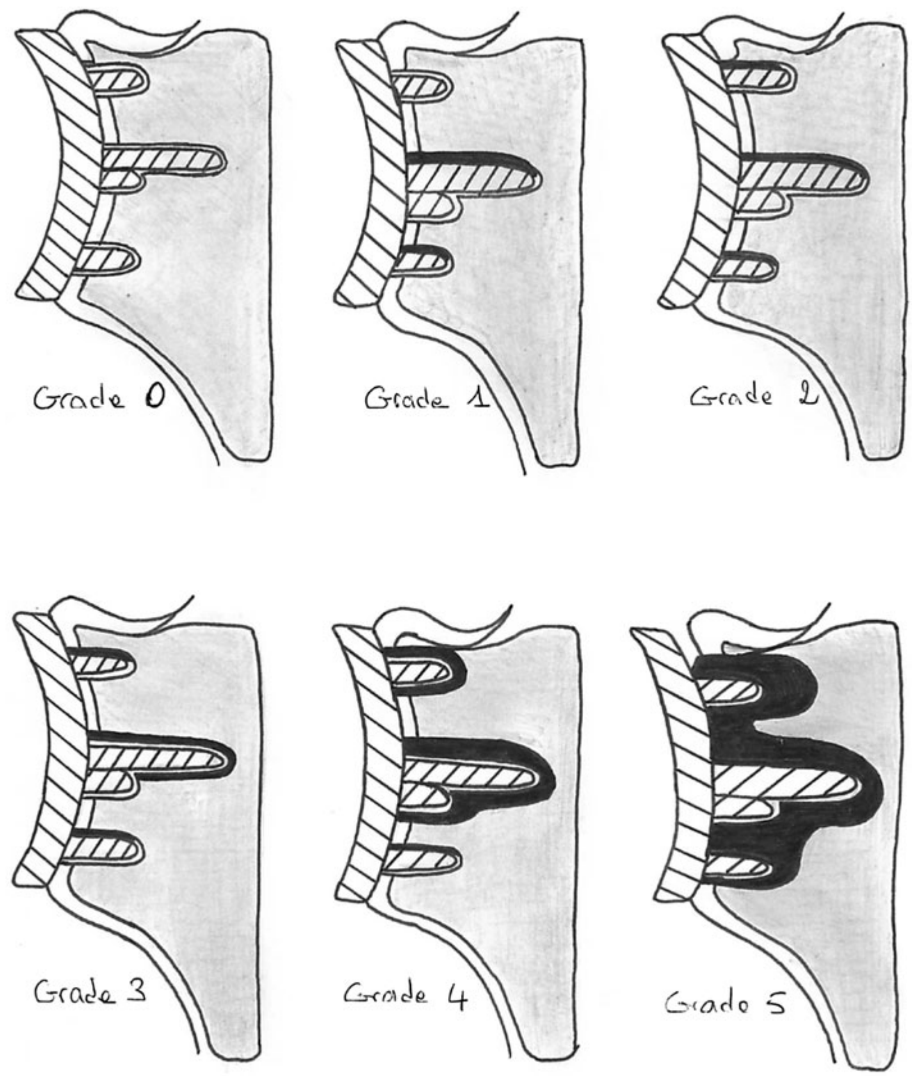


Fig. 11 Grading system to assess radiolucencies at the cement–bone interface of pegged glenoid component according to Lazarus [17]

component as the fixation method is not relevant to the component–subchondral bone interface.

Grade A Complete component seating.
Grade B <25 % incomplete contact, single radiograph.
Grade C 25–50 % incomplete contact, single radiograph.
Grade D <50 % incomplete contact, both radiographs.
Grade E >50 % incomplete contact, single radiograph.

Classification and radiographic assessment of radiolucent lines of the cemented glenoid component according to Mileti [19] (Fig. 13)

The radiographic projections are used for the analysis including a 40° posterior oblique (true antero-posterior) projection in both internal and external rotation and an axillary projection. The glenoid components are divided into six zones for evaluation of periprosthetic lucency. The presence, location and thickness of the lucent lines are assessed. The maximum thickness of the lines is measured to the nearest 0.5 mm (0.5, 1.0, 1.5 and 2 mm). The observers also independently judged component position change on the two sets of radiographs by assessing the glenoid for medial migration or tilting. A change in position was determined to have occurred if two of three or all three observers identified a change. A glenoid component was considered to be at risk for clinical loosening if at least two of three independent observers identified migration or tilt of the component or if a complete lucent line is present and some part of it is 1.5 mm or greater in width.

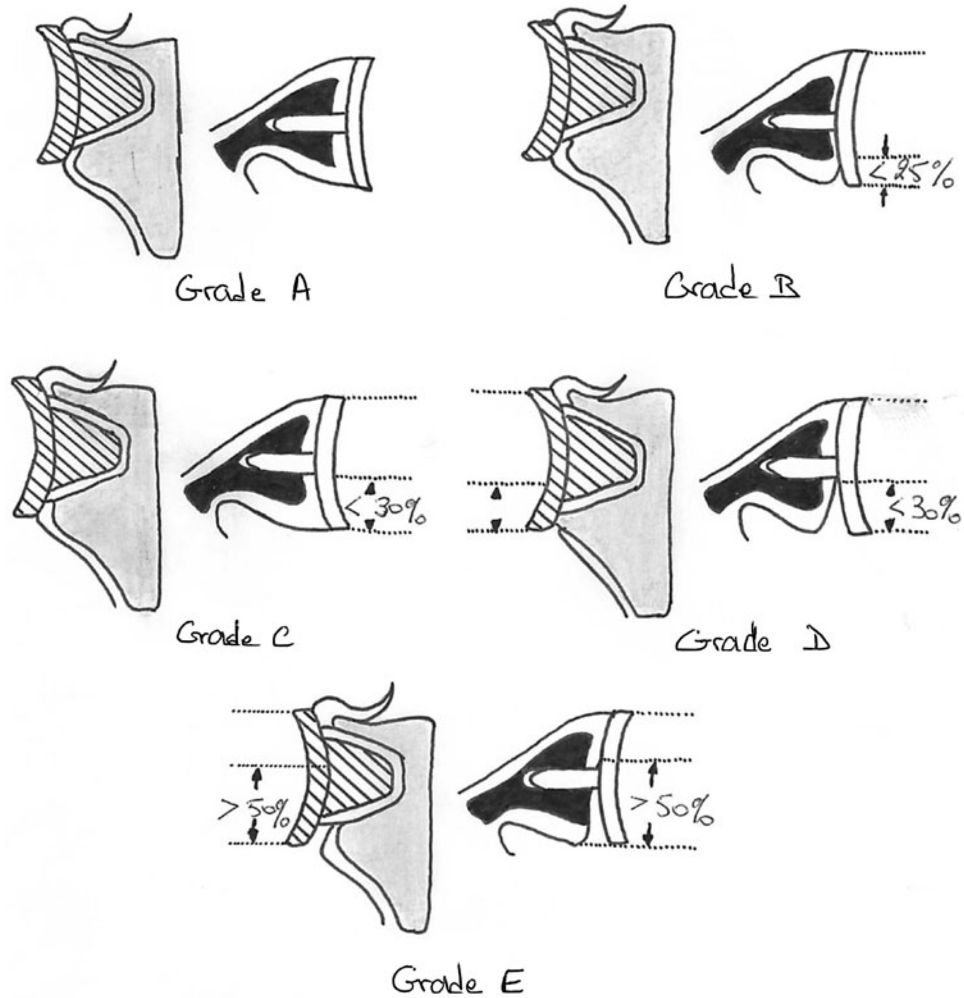


Fig. 12 Grading system used to assess radiolucencies at the component–subchondral bone interface (seating) according to *Lazarus* [17]

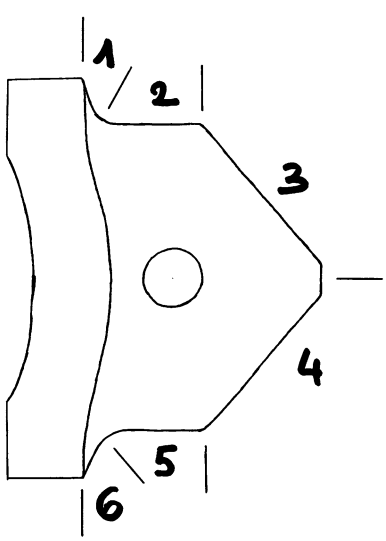


Fig. 13 Zonal locations of analysis of lucent lines according to Mileti [19]

Conclusion

Classifications serve as a basis for establishing the degree of severity and thus a prognosis. Treatment options and procedures can be planned. Careful assessment of the state of the glenoid or component glenoid is essential.

Conflict of interest The author is "Arrow shoulder prosthesis" designer.

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