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Origin of proximal femur fracture classification and their namegivers

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Due to the high incidence of proximal femoral fractures, classifications of these fractures are often used in daily practice. Most classifications are eponymous terms since they bear the name of the person(s) who developed them. In this study we provide an insight in the origin of the classifications and the background of their name givers. The clinical implication and background of the eponymous proximal femur fracture classifications of Garden, Pauwels and Evans-Jensen are discussed.

With the rising use of modern classification systems, the relevance of historically important classifications is food for discussion. Nevertheless, these classification systems are still used in daily communication and decision making.

Keywords: Eponyms, hip, fracture, history, orthopaedics.

INTRODUCTION

Fractures of the proximal femur are among the most common fractures[1]. In decision making about diagnosis and treatment of proximal femoral fractures, classification systems are commonly used in daily practice. Several classification systems are known by their eponymous term.

Eponymous terms are common in medicine. Despite they are used frequently, the original meaning is often no longer known or the meaning has changed over time with new insights[2]. Nevertheless the eponymous terms are used in daily practice and for research purposes too. To help and prevent miscommunication we present a selection of eponymous classifications with the original publication on which they are based. This is accompanied by a biography of the name giver(s) and a discussion of clinical implication. With this we aim to prevent confusion when using these terms and give some depth and human face to our profession.

Some of the most used classification systems regarding proximal femoral fractures will be described.

RESULTS

Pauwels classification

The original

Pauwels wrote an extensive work on the femoral neck fracture. He elaborates on the effect of shearing and compressive stresses on bone healing. He divides the femoral neck fractures in three subtypes (Figure 1):

Type I: Inclination of the fracture line up to 30 degrees. Compressive forces are predominant and therefore internal fixation is not needed.

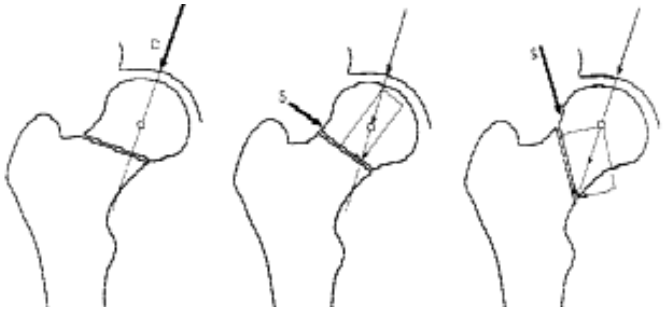

Fig. 1 — Original Pauwels'classification; type 1 (left), type 2 (middle) and type 3 (right)[5].

Type II: Inclination of the fracture line between 30 and 50 degrees. In these fractures shear forces negatively influence the healing. Internal fixation is needed to eliminate these forces.

Type III: Inclination of the fracture more than 50 degrees. The shearing stress dominates and is associated with significant varus force. This results in displacement and varus collapse. The stresses can be eliminated by valgus osteotomy[2].

The man

Friedrich Franz Karl Maria Pauwels (Figure 2) (May 23, 1885 - January 19, 1980) was born in Aachen, Germany. Pauwels studied natural sciences in Lausanne from 1906 to 1907 and then medicine in Freiburg im Breisgau. After Pauwels passed the state examination in 1911 and completed his doctorate in the same year, he initially worked in Dresden, Berlin and Vienna. In 1913 he took over the management of the medico-mechanical Zander establishment (physiotherapy 'avant la lettre') in Aachen. From 1924 to 1934, Pauwels then headed the newly established orthopedic department at the Luisenhospital in Aachen as chief physician. In 1934 he switched to the municipal hospitals, which would later become the Aachen University Hospital, where he was the founding director of the orthopedic clinic, a seat he retained until 1960.

As part of his orthopedic work, Pauwels always dealt with the biomechanical foundations of the skeletal system and the biomechanics of bone healing. He defined the ability of the bone and its mesenchymal cells to react to different types of forces (tension, pressure, shear) through differentiation in tissue types and therefore with functional adaptation. In 1927, for the first time, due to biomechanical planning, he successfully treated a femoral nonunion. Pauwels was particularly interested in three diseases of the hip joint: femoral neck nonunion, coxa vara in children and coxarthritis. In 1958, he introduced the principle of tension strapping (tension band or zuggurtung) from reinforced concrete construction into the fracture treatment of fractures of the patella and the olecranon, whereby tensile structures on the fragments (wire loops) could trigger a pressure effect on the fracture gap under load. In 1973 Pauwels published an atlas on the biomechanics of healthy and diseased hips, in which he also established the Pauwels classification for the division of femoral neck fractures. Pauwels married twice, first with Eugène Pidoux from Switzerland and in his second marriage with Sibylle Königs from Hilfarth, Germany[4].

Fig. 2 — Friedrich Franz Karl Maria Pauwels[4].

Clinical implication

Pauwels' classification has some practical limitations and is therefore currently used less then Garden's classification for decision making about treatment. The correct degree of inclination is difficult to determine on anterior-posterior x-rays of the pelvis preoperatively. Furthermore, in contrast to Pauwels' classification, nowadays internal fixation not only plays a role in type II but in young patients with type III as well. Besides that, the role of arthroplasty in the treatment of femoral neck fractures is not included in the classifications treatment propositions.

In literature a common incorrect citation of the classification occurs due to misinterpretations about the angle of inclination of the fracture line. This misunderstanding is probably based on a confusion in the original work of Pauwels. In a figure regarding his classification, numerical values of the three types were mentioned in the accompanying text. However the German text describes the upper values of each type (30, 50 and 70 degrees) and with that, the confusion occurred (5). A correct interpretation classifies type 1 as 0-30 degrees, type 2 as 30-50 degrees and type 3 as 50 degrees and above.

Garden classification

The original

Garden put down his classification in 1961 (Figure 3). He described four stages of subcapital fracture.

Stage I was an incomplete subcapital fracture. The fracture of the inferior cortical buttress is greenstick in nature, and a minimal degree of lateral rotation

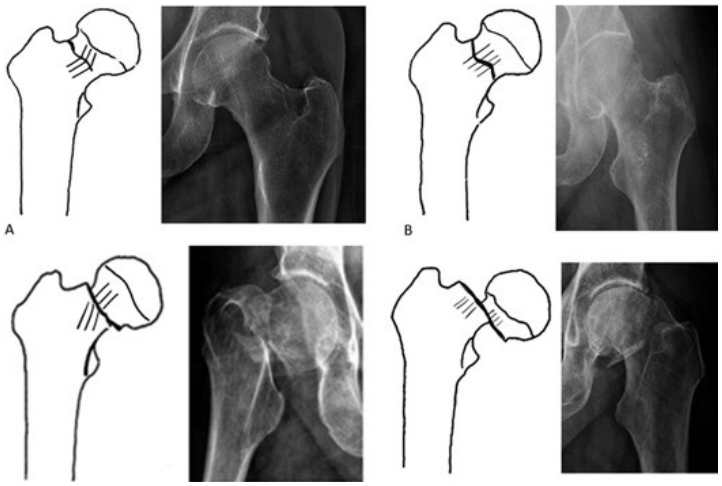

Fig. 3 — Original Gardens classification[21].

of the distal upon the proximal fragment creates the radiological illusion of impaction. The medial lamellae of the internal weight-bearing system in the distal fragment lie in abduction as compared with those in the capital fragment which, itself, is adducted. If unprotected, this fracture may at any time become complete.

Stage II was a nondisplaced complete subcapital fracture. The inferior cortical buttress has been broken, but no tilting of the capital fragment has taken place. As in the Stage I fracture, the closely opposed fragments in this complete fracture may succumb to lateral rotation forces and show the classical displacement of "subcapital separation."

Stage III is a stage II with partial displacement. The two fragments retain their posterior retinacular attachment, and crushing of the posterior cervical cortex has not yet taken place. Lateral rotation of the distal fragment therefore tilts the capital fragment into abduction and medial rotation as shown radiologically by the direction of the medial weight-bearing lamellae in the femoral head. If the tendency for the limb to rotate laterally is not resisted by external or internal fixation, stripping of the retinacular attachments and crushing of the thin posterior cervical cortex will allow the full displacement (stage IV) to occur.

Stage IV is a complete subcapital fracture with full displacement. This stage is reached when the retinacular hinge is detached from the posterior surface of the neck and collapse of the posterior cortical shell has taken place. The fragments are then divorced from each other, and the capital fragment at once returns to a more normal position in the acetabulum. Its medial weight-bearing lamellae are then seen radiologically to lie in alignment with their fellows in the pelvis[6].

The man

Robert Symon Garden (Figure 4) (August 2, 1910 – October 16, 1982) was born at Macduff, Banffshire. He was educated at Robert Gordon's College, Aberdeen and at Marischal College, Aberdeen University, where he graduated in 1934. He was an orthopedic registrar to Professor TP McMurray at David Lewis Northern Hospital and the Royal Liverpool Children's Hospital. After the Second World War he was appointed as consultant orthopedic surgeon to the Preston and Chorley Group of Hospitals where his skill built up a first-class orthopedic and accident unit. He was especially interested in the functional anatomy of the femoral neck and devised the generally accepted classification of sub-capital fractures of the femur,

Fig. 4 — Robert Symon Garden.

including an ingenious method of fixation by placing two screws at an angle. He was a man of exceptional intellectual honesty who was always careful to point out the imperfections of his own line of treatment for fractures of the femoral neck on which he wrote a number of papers.

He was a Fellow of the British Orthopaedic Association, a member of the Societé Internationale de Chirurgie Orthopédique et de Traumatologie, lecturer at the University of Liverpool, and was especially pleased by his election to the FRCS in 1970. He had been active in the BMA and was chairman of the local division in 1967. He married his wife Janet Ann McHardy in 1939. They had two children, a son and a daughter. Outside his professional work he was interested in photography, fishing and English literature, and ill health compelled his early retirement in 1974. Only a few years later he suffered further illness which resulted in permanent and serious incapacity[7].

Clinical implication

Despite that the inter- and intra-rater agreement of the Garden classification is demonstrated as relatively low, it remains the most used classification in femoral neck fractures. Currently, this classification is in 72% of surgeons the preferred femoral neck fracture classification[8]. The perceptions about the Garden classification among surgeons showed that reliable differentiation between Garden type I and II versus Garden type III and IV can be made easily. Furthermore, 96% of surgeons believed they could differentiate between these types. Nevertheless, differentiation between Garden type I versus II and type III versus IV is difficult. Only 39% of surveyed surgeons, felt they could differentiate between these types[8,9].

Evans-Jensen Classification

The original

This classification of intertrochanteric fractures is originally described by Evans (Figure 5A).

He divided the trochanteric fractures into two main types, depending on the direction of the fracture line. In type 1 fractures, fractures run from the lesser trochanter upwards and laterally outwards. Type 2 runs oblique reversely. Type 1 consists of 4 subgroups. In type 1, subgroup 1, the inner cortical buttress is not disturbed and is undisplaced. In subgroup 2 the overlap of the cortical buttress can simply be reduced. Subgroup 1 and 2 are considered as stable. In subgroup 3 the cortical buttress cannot completely be reduced and in subgroup 4 the cortical buttress is comminuted and can neither be reduced. Subgroup 3 and 4 are unstable and tend to heal in varus. In type 2 fractures the femoral shaft has the tendency to displace inwards and is unstable too.

Jensen modified this Evans classification into the 5-type classification of Evans-Jensen (Figure 5B). Jensen described that he modified the classification by including the fracture type with a reversed oblique line and large greater fragment into type 3 and with

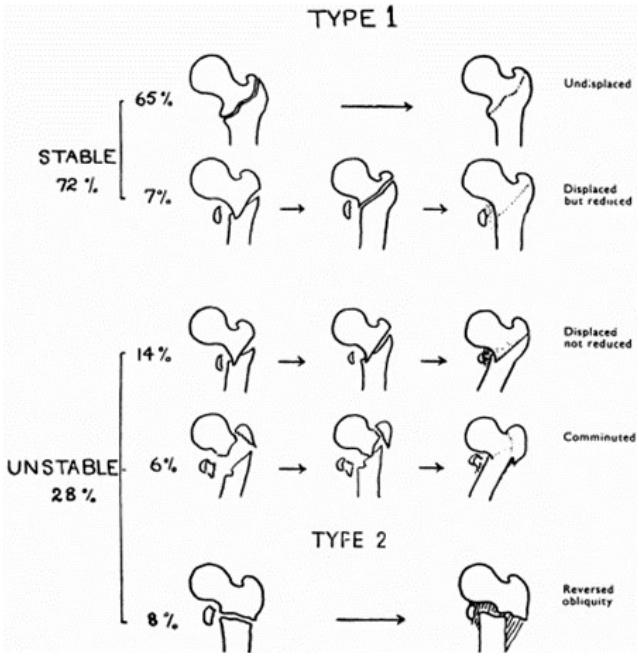

Fig. 5A — Original Evans' classification (left).

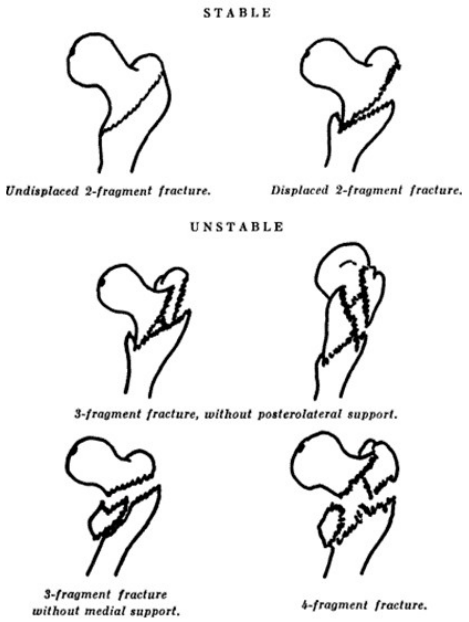

Fig. 5B — The modification by Jensen (right)[10,12].

that modified the system from 6 to 5 types. Evans-Jensen type 1 is an undisplaced 2-fragmentary fracture and type 2 a displaced 2-fragmentary fracture, which both are considered as stable. Type 3 is 3-fragmentary without posterolateral support, type 4 is 3-fragmentary without medial support and type 5 is 4-fragmentary. Type 3 to 5 are considered as unstable fractures[10-12].

The men

Edward Mervyn Evans

Edward Mervyn Evans (Figure 6), was born on 13 February 1913. He was educated at Uppingham, from which he won a classics scholarship to King's College, Cambridge. The sudden death of his father from pneumonia freed him from the pressure of following his father's wishes for him to have an academic career, and he switched to medicine, which was of increasing interest to him. He trained at the Middlesex Hospital, qualifying in 1937.

When war broke out he joined the surgical team as registrar at the Middlesex, where he was one of three surgeons working through every night on victims of the Blitz. There was no direct senior supervision and it was truly a massive self-taught lesson in the management of major trauma. Thereafter, he worked in Hatfield, to take part in the preparation of a surgical hospital due to be shipped out to Burma, and was subsequently drafted to Burma to set it up. During the journey round the Cape he was diverted to the Middle East once it was known Singapore had fallen. After the war he completed his orthopaedic training at the Middlesex and was appointed to lead one of the three trauma teams at the Birmingham Accident Hospital. In 1950 he worked as one of only two orthopaedic surgeons west of Cardiff, based in Morriston Hospital, Swansea, till the end of his career. He worked with Essex-Lopresti among others. He wrote notable papers on hand injuries and forearm fractures. He was co-author in the first description of particulate fragment sensitivity due to chrome-cobalt following total hip replacement. He married Muriel Amison in

Fig. 6 — Edward Mervyn Evans[13].

1938, who died one week before he did. They had two children, a daughter and a son, David, who became a plastic surgeon. He died on 23 December 200013.

Jorgen Steen Jensen

Jorgen Steen Jensen was an orthopedic surgeon from Denmark. He worked at the Rigshospitalet in Copenhagen. He was one of the 26 founders of the Study Group in 1982 which would be transformed into "European Bone and Joint Infection Society" on the 20th April 1993[14]. Jensen focused on research regarding synovectomy in septic arthritis[15]. He was one of the founders of a new methyl methacrylate, n-decyl methacrylate, isobornyl methacrylate (MMA/DMA/IBMA) bone cement called "Boneloc"[16]. This innovation with theoretical advantages with a new formula and a shorter handling time was widely used in arthroplasty in the early nineties. Due to high short- and long-term revision rates caused by aseptic loosening, "Boneloc" was withdrawn in 1995[17,18].

Clinical implication

Jensen reported only a slightly modified classification of Evans, by just including the reversed oblique fracture into type 3, however an accurate look on both classifications reveals more differences. Evans subgroup 1 (with undisturbed inner cortical buttress) is divided into Jensen 2-fragmentary fracture type 1 and type 2. Jensen type 3, a 3-fragmentary fracture without posterolateral support, is not described by Evans and seems to be introduced by Jensen. Jensen type 4, a 3-fragmentary fracture without medial support, arises from Evans subgroup 2 and 3, fractures with a disturbed inner cortical buttress. Jensen type 5, a 4-fragmentary fracture, is similar to Evans subgroup 4. As described by Jensen, Evans type 2, the reversed oblique fracture, is included in Jensen type 3, however that is not shown in the figures in his original article.

Fractures with a reversed fracture line have a higher risk of fixation failure and are therefore important to recognize. In the original classification of Evans, a trochanteric fracture with a reversed type was categorized as a type 2 fracture. Despite the clinical importance of recognizing this reversed fracture type, it is not separately mentioned in the modification of Jensen.

The inter- and intraobserver reliability of the Evans-Jensen classification shows fair to moderate agreement when applied by experienced orthopaedic surgeons. Which is a poorer reliability compared to the AO classification for intertrochanteric fractures with the use of AO main groups, but not in comparison to AO subgroups[19,20].

DISCUSSION

Due to the high incidence of proximal femoral fractures, classifications of these fractures are often used in daily practice. The aim of this study was to provide an insight in the origin of the classifications and a background of their name givers.

Literature shows variation of interpretation of hip fracture classifications. For example, only 39% of surgeons can differentiate between Garden type I versus II and type III versus IV and the inter- and intraobserver reliability of the Evans-Jensen classification shows fair to moderate agreement[8,19]. Disagreement between professionals about interpreting hip fracture classifications can lead to miscommunication. This indicates the importance of a correct understanding of the background of these classifications to prevent incorrect choice of treatment.

The presented classifications are historically important in the diagnosis and treatment of proximal femoral fractures. However, the rising use of modern classification systems as the AO classification, leads to decreased attention to historical classifications. With this, the historical context of classifications as Garden, Pauwels and Evans-Jensen seems to fall behind. Furthermore, due to the many AO subgroups, the inter- and intraobserver reliability is not different compared to Evans-Jensens[19,20].

In conclusion, the management of hip fractures is influenced by classification systems that are often eponymous. These classifications were presented by their name givers several decades ago and became important decision making tools in hip fracture surgery. Since these classification systems are still used in daily communication and decision making, it is paramount to understand their historical context. Only with this understanding the current clinical implication can be discussed and the classifications properly used.

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