NOAJ

SPECIAL EDITION

HIP FRACTURES IN ADULTS

AUTHORS

Ashok Kumar Banskota[1]

AFFILIATIONS

[1]Professor, Department of Orthopedics, B. & B. Hospital, Lalitpur Hospital and Rehabilitation Center for Disabled Children (HRDC), Banepa, Nepal

CORRESPONDENCE

Ashok Kumar Banskota
Professor, Chairman, Department of Orthopedics, B. & B. Hospital, Lalitpur Hospital and Rehabilitation Center for Disabled Children (HRDC), Banepa, Nepal
Email: ashokbanskota@gmail.com

REVIEW ARTICLE

Hip Fractures: Historical Perspectives

Abstract

https://doi.org/10.59173/noaj.20251104b

Hip fractures demand urgent attention in low- and middle-income regions as much as in the West. Their global burden is enormous: over 10 million hip fractures occurred worldwide in people ≥55 years in 2019, and projections suggest they will nearly double by 2050. Hip fracture projections in Nepal estimate ~6,900 cases in 2015 (age ≥50) rising to ~23,400 by 2050. Treatment of hip fractures have evolved slowly over the centuries. The first successful internal fixations appeared in the 1870s with steel wiring to unite a femoral neck fracture. The 20th century saw dramatic advances in the treatment of hip fractures. Key categories of modern fixation techniques include cannulated cancellous screws, sliding hip screws, cephalomedullary nails, and Arthroplasty. This article discusses historical context, evolution of hip fracture treatment, pioneers in hip fractures treatment and currently available fixation devices for hip fractures.

KEYWORDS

Hip Fractures; Fracture Fixation, Internal; Arthroplasty, Replacement, Hip; Orthopedic Fixation Devices; Traction

Introduction

Hip fractures are one of the major causes of morbidity and mortality in older adults. Their global burden is enormous: over 10 million hip fractures occurred worldwide in people ≥55 years in 2019, and projections suggest they will nearly double by 2050.[1] In practical terms, "one in three women and one in five men over age 50 will experience an osteoporosis-related fracture", and up to 20–24% of hip fracture patients die within one year of injury.[2] Aging populations in Asia mean enormous growth in fractures there: for example, hip fracture projections in Nepal estimate ~6,900 cases in 2015 (age ≥50) rising to ~23,400 by 2050.[3] Even with such high volumes, the hip fractures still remain unsolved. South and Southeast Asian countries face similar trends, often with limited resources for orthogeriatric care.[4] In Nepal, for instance, up to 20% of older hospital patients have osteoporosis and risk of fragility fractures, including hip fractures.[5] These fractures require early operative fixation because "the most conservative management for hip fracture is surgery".[6] Thus, hip fractures demand urgent attention in low- and middle-income regions as much as in the West. This review explores the historical development of hip fracture treatment, profiling its pioneers and evaluating current fixation devices.

Historical Context

Treatment of hip fractures evolved slowly over the centuries. Ancient surgeons like Hippocrates (~400 BC) used traction and splinting; Hippocrates himself described the use of pulleys to align femoral fractures. Early physicians (Paul of Aegina, 7th century) noted dangers of excessive tight bandaging. No reliable internal fixation existed until the 19th century.[7]

In 1819, Sir Astley Cooper first classified hip fractures by location, distinguishing femoral neck breaks from trochanteric fractures.[8] Surgeons such as Bernhard Langenbeck (1850s) attempted pin fixation (often with fatal infection).[9] The first successful internal fixations appeared in the 1870s: Friedrich König in 1875 used steel wiring to unite a femoral neck fracture.[9]

The term "calcar femoris" and its significance for the stability of fractures in this region was described by Robert Adams (1791 – 1875), in the encyclopedia of anatomy and physiology of man, Vol II written by R. B.Todd (1809-1860).[10] Abraham Colles (1773-1843), popular for his description of distal radius fractures, is less known for his work on fracture neck of femur where he reported description of 11 cases in 1881.[11] It is likely that he was the first to describe an impacted fracture of the neck of the femur, reporting three cases.[11] He also described and illustrated with a drawing a case which today would be classified as an unstable trochanteric fracture and another of nonunion of an intracapsular fracture.[11] Robert William Smith (1807-1873), published a paper on the diagnosis of fractures of the neck of the femur.[12] His two senior colleagues, Colles and Adams, are mentioned in a lengthy chapter on femur neck fractures in his most significant monograph, which was published in 1850.[13] Bernhard Rudolph Konrad von Langenbeck (1810-1887) was among the first surgeons to perform internal fixation on an non-healing femur neck fracture.[9,14]

Cooper and Travers presented the first extensive description of fractures of the neck of the femur in "surgical essays" in 1819.[15] They divided these fractures into intra- and extracapsular according to their prognosis and described in detail the clinical and cadaver findings, in a way which still remains relevant today.[15] They also discussed the healing of intracapsular fractures and suggested that they heal only by fibrous tissue. This view was prevalent thereafter for many years. They also referred to fractures below the trochanter (subtrochanteric fractures) and described the characteristic displacement of the proximal fragment: "The upper end of the bone is drawn forwards and upwards, so as to form nearly a right angle with the body of the thigh-bone, the cause of this is evidently the contraction of the iliacus internus and psoas muscle".[15]

Earle Fracture bed (1823)

Henre Earle (1789-1838) received the "Large Gold Medal" of the Society for the Encouragement of Arts, Manufactures, and Commerce for his "Bed for Patients under Surgical Treatment" published in 1821.[16](Figure 1) He further expanded it in 'practical observations in surgery' in 1823, then re-designed and reviewed it in the Lancet in 1824.[17] The device provided comfort for the patient and allowed treatment of the femoral neck fracture in semiflexion. Mr. Earle was of the opinion that these cases may be cured by long continued attention in keeping the parts at perfect rest. His colleagues at that time "wished him success in his laudable attempt to prevent the lameness and shortening of the limb in cases of fracture within the capsule".[18,19]

The 20th century saw dramatic advances in the treatment of hip fractures. In 1904 an early traction table was introduced by H. König, and by the 1920s X-ray imaging and anesthesia enabled better fixation techniques.[19] In the 1920s–30s Smith–Peterson developed his famous spiked vitallium nail for femoral neck fractures (1925–31), yielding reasonable union rates.[20] American orthopedic surgeon Lawson Thronton (1885-1957) first developed the nail plate osteosynthesis for hip fractures in 1937 using Smith-Peterson nail.[21] This system was later popularized by Harrison L. McLaulign as "McLaulign nail-plate" in 1947.[22] (Figure 2 and 3)

In 1930s, some osteotomies, such as Pauwels osteotomy and McMurry osteotomy, were devised to treat femoral neck fractures.[23,24] Thomas Porter McMurry, a British Orthopedic Surgeon, developed medial displacement intertrochanteric osteotomy in 1936.[24,25] (Figure 4) The combination of compressive loading force and vascularity at the intertrochanteric region helped to achieve bony union in an otherwise very challenging, high non-union fractures.[25] This procedure has been one of the commonly performed surgeries in resource limited settings and provided successful results.[26,27] However, this procedure had two major disadvantages, viz. shortening and necessity of extended recumbency, resulting in increased rate of complications.[25,27] This resulted in the decline of its popularity as a primary treatment method for femoral neck fractures.

After World War II, diverse fixation devices emerged: Jewett and others devised angled blade plates, and in the 1950s Ernst Pohl (Germany) patented the first dynamic hip screw (DHS) for trochanteric fractures.[28–30] (Figure 5)

Austrian Surgeons Hans George Ender and his colleague Simon widener developed condylocephalic nailing (also known as Ender's nail) for hip fractures in 1970.[31] However, higher rate of complications, both radiographic and clinical, were observed with Ender's Nail compared to Thronton's and McLauglin's nail-plate systems.[32] The AO (Arbeitsgemeinschaft für Osteosynthesefragen) group standardized plating and nailing techniques in the 1960s–70s.[33] In 1990, an American orthopedic surgeon named Robert J. Medhoff developed a sliding plate, aka Medhoff's plate.[34] By the late 20th century, modern implants (sliding screw-plate devices, cannulated screws, intramedullary hip nails) had transformed the management.[30]

The Austin Moore prosthesis, developed by American orthopedic surgeon Austin T. Moore in the 1940s is a classic uncemented monoblock hemiarthroplasty implant first implanted in 1943.[35,36] Similarly, Thompson hemiarthroplasty was developed by Fredrick R Thomson and first inserted in 1951.[37,38] Metal-on-metal hip replacement began in the 1950s (McKee–Farrar prosthesis), and by the 1960s Sir John Charnley's low-friction THA revolutionized hip surgery (though Charnley's work was aimed at arthritis, it later influenced fracture care).[39,40]

Pioneers in Hip Fracture Treatment

Hugh Owen Thomas (1834–1891) – Britain

Hugh Owen Thomas was a descendant of a bone setter's family and practiced extensive treatment of fractures and joint diseases.[42] He used well-padded wooden splints to maintain bone alignment and protection.[42] He emphasized the importance of proper long rest during the treatment of joint disease. In 1865, he introduced the Thomas Splint, which is a simple, easy-to-use, and effective stabilizer for femoral fractures.[43] The splint was widely used among the British Military during World War I and reduced mortality from 80% to 8%.[44]

Ernst Pohl (1876–1962) – German

Ernst Pohl was a genius German who designed the intramedullary hip nail.[28] He started his extraordinary work to develop an implant when his mother died due to a proximal femur fracture treated with conservative methods of traction and immobilization. He decided to develop an implant that could stabilize the fracture fixation, help with early mobilization, and facilitate fast recovery.[45] Finally, he developed the most widely used two basic implant designs—the dynamic hip screw (DHS) and the intramedullary hip nail (IMHN)—for the fixation of trochanteric fractures.[28,45,46] He is also known for

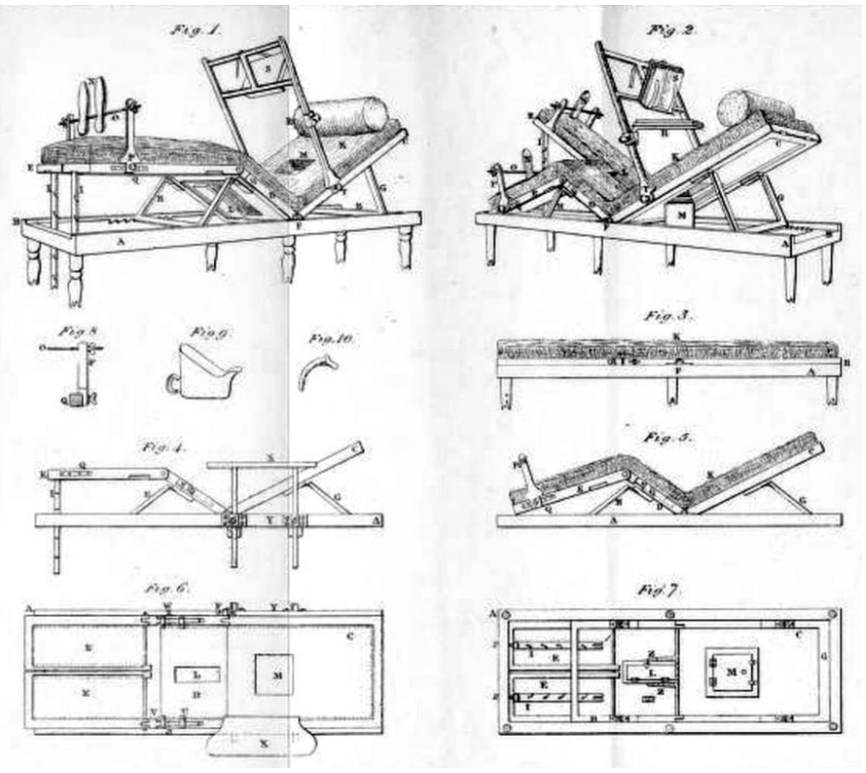

Figure 1 Design of Earle's Fracture Bed
(Taken from the book practical observation in surgery by Henry Earle[17]

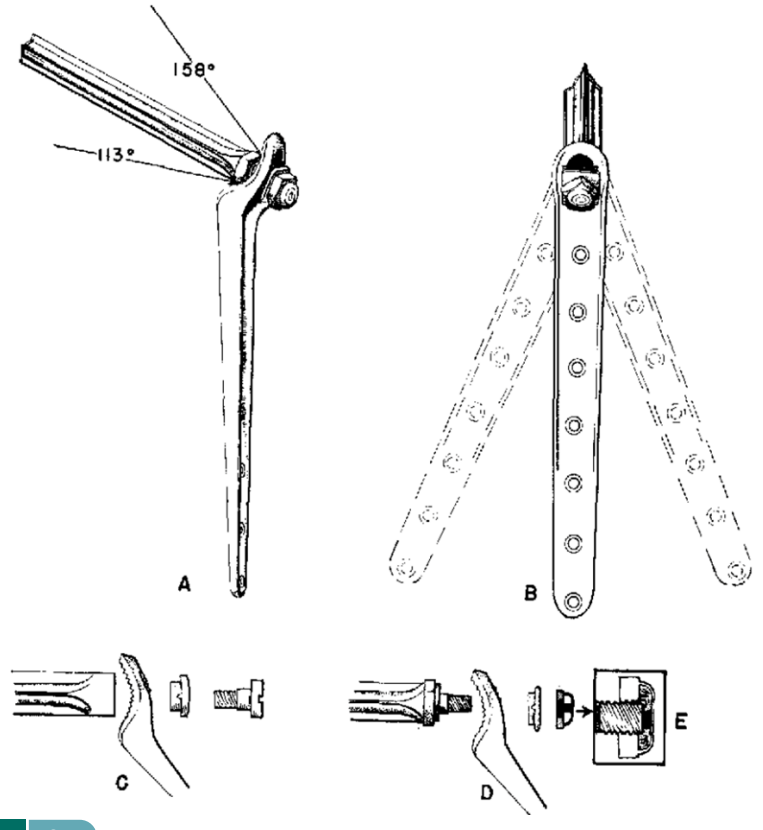

Figure 2 Adjustable hip fixation device, A and B, adjustability of nail-plate relationship is available in two planes. C, undependable "set screw" locking mechanism. D, dependable "stop nut" locking mechanism. F, the "stop nut" with enclosed elastic washer which, when compressed by stud, prevents loosening (Picture taken from Harrison L. McLaughlin's Original Article[22])

Evolution of Hip Fracture Treatment: A Historical Timeline

(Adapted from Rang: The Story of orthopedics[41])

1575	Ambroise Pare describes intracapsular fractures and says that they go on to nonunion because they are bloodless.		
1822	Astley Cooper says of intracapsular factures, "I have never met with one in which bony union had taken place." He did animal experiments – intracapsular fractures went to non-union while extracapsular fractures united.		
1850	B.R.C. Langenbeck, inventor of the retractor, nailed a hip fracture.		
1870	Langenbeck's Ivory pegs failed.		
1878	Konig: First successful open reduction with internal fixation for hip fracture.		
1883	Senn's experiments on animals with hip fractures show that the union rate is better with internal fixation than with cast. However, he meets with such opposition that he continues to treat patients with a cast.		
1898	Broeckmann and Gillette use open reduction and bone peg.		
1898	Gillette's Ivory pegs		
1904	Whitman's plaster is the standard.		
1907	Delbert begins to use closed reduction and screw fixation using only an anteroposterior radiograph and a jig.		
1912	Albee: Open reduction and bone peg		
1914	Preston adds a side plate to a screw to prevent varus.		
1922	Martin and King of New Orleans introduce closed fixation with nail and X-ray.		
1930	Hey Groves uses bone pegs.		
1930	Commission on hip fractures.		
1931	Smith-Petersen uses a triflanged nail combined with open reduction.		
1932	Leadbetter devises a method of closed reduction.		
1932	Westcott of Virginia performed closed nailing with a solid triflanged nail.		
1932	Sven Johansson uses a cannulated nail and closed reduction. Although various kinds of nail had been tried for 30 years, the results were not good enough to be generally used. The cannulated triflanged nail and closed reduction captured the imagination of most orthopaedic surgeons.		
1934	Thornton bolts a plate onto a triflanged nail to prevent varus.		
1935	Telson and Ramsohoff: multiple thin pins	1941	Jewett's one-piece nail plate
1936	Knowles pins	1955	Pugh's sliding nail plate
1937	Moore's pins	1957	Charnley's compression hip screw

his significant contribution to the development of various radiological and surgical devices.[28]

Smith-Peterson (1886–1953) – America

Smith-Peterson, an American orthopedic surgeon, is known for his significant contribution to fracture fixation and hip arthroplasty.[9,19,20] He reported his successful use of stainless-steel tri-flanged nails for femoral neck fractures in 1931.[20] The three-flanged nail known as the Smith-Petersen (SP) Nail, was a revolution for the treatment of femoral neck fracture.[20] SP Nail underwent several design updates and was eventually superceded by the sliding hip screw.[47]

Sir John Charnley (1911–1982) – Britain

Sir John Charnley is remembered for his fracture management by introducing a 120° dynamic sliding screw in 1957, for surgical treatment of hip fractures.[48] He is best known for the modern low-friction total hip arthroplasty (THA).[49,50] He spent almost two decades modifying and refining his clinical surgical practice and procedures. He is also renowned for designing walking calipers and a modified Thomas splint.[51]

Maurice E. Müller (1918–2009) – Switzerland

Müller was one of the founding members of the AO (Arbeitsgemeinschaft für Osteosynthesefragen or Association for the Study of Internal Fixation) Group (1958), which revolutionized fracture treatment by promoting stable internal fixation using metal implants.[33] He established four principles of fracture management, including anatomical reduction, rigid fixation, blood supply preservation, and early mobilization, that greatly improved healing and patient outcomes.[33] His internal fixation techniques are critical in the treatment of intracapsular or extracapsular hip fractures. He

advocated the use of cannulated screws or dynamic hip screws (DHS) to manage the femoral neck fractures. He used a DHS or intramedullary nail for intertrochanteric fractures, while interlocking nails or long plates were employed for subtrochanteric fractures.[33]

Implant & Fixation Evolution

Innovations in implants have continually improved outcomes. (Figure 6)

Key categories of modern fixation include:

Cannulated screws:

Simple screw fixation for nondisplaced femoral neck fractures was popularized in the mid-20th century. Today, multiple small (6.5–7.3 mm) cannulated cancellous screws (with washers) can fix many Grades I–II neck fractures. (Some early designs date to the 1930s but widespread use grew in the 1970s–80s.).[8,9,30]

Sliding screw-plate (DHS):

The dynamic hip screw was first introduced by Pohl (Germany, 1955) and refined by the AO group.[28,33] A large lag screw into the femoral head is coupled to a side plate on the shaft, allowing controlled impaction. DHS is ideal for many stable intertrochanteric fractures. It dominated extra-capsular fixation by 1980s.

Cephalomedullary nails:

Intramedullary nails passed through the greater trochanter and carrying a lag screw to the head. The first clinical "Gamma Nail" appeared in 1988.[52] Modern systems (PFNA, INTERTAN, etc.) provide minimally invasive fixation for unstable trochanteric and subtrochanteric fractures.[53]

Arthroplasty:

Older patients with displaced femoral neck fractures often receive hip replacements.[54] Historically, Moore and Thompson hemiarthroplasty prostheses (1930s–50s) were used (Figure 7 and 8); from the 1960s on, total hip arthroplasty (Charnley, 1961) also became standard in selected cases.[54,55] Today cemented or cementless stems with large heads deliver more predictable mobilization than fixation in frail elders.[55]

Figure 3 Smith-Peterson Nail on Thornton Plate (National Museum of Health and Medicine Photo by Kevin Sommer Giron, Silver Spring, Maryland, United States 08.12.2025)

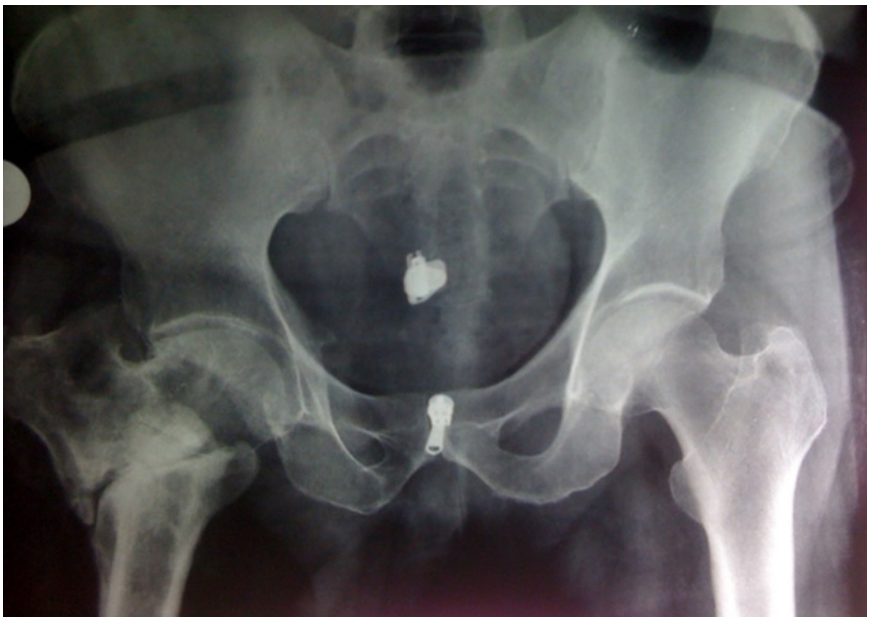

Figure 4 McMurry's Medial Displacement Osteotomy for Femoral Neck Fractures

Conclusion

The understanding and management of hip fractures have evolved considerably. However, the standard care remains early operative fixation because "the most conservative management of hip fracture is surgery". Improvements in classification of injury, choices of fixation devices for specific fracture types, advances in orthogeriatric care and osteoporosis management, and advances in metallurgy, implant designs, and arthroplasty has significantly improved hip fracture care. With an anticipated increase in these challenging fractures in the coming decades, a thorough knowledge of prevention strategies as well as optimal multi-disciplinary treatment pathways is the need of the hour in managing hip fractures.

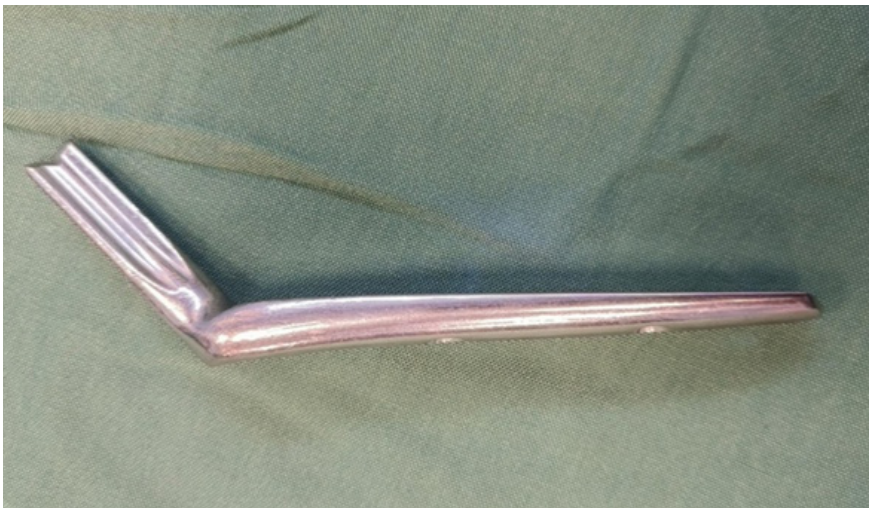

Figure 5 Jewett Nail Plate

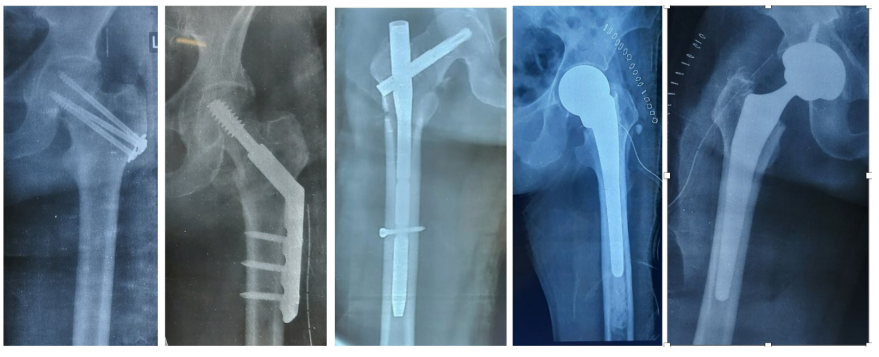

Figure 6 Variety of implant used in hip fracture fixation

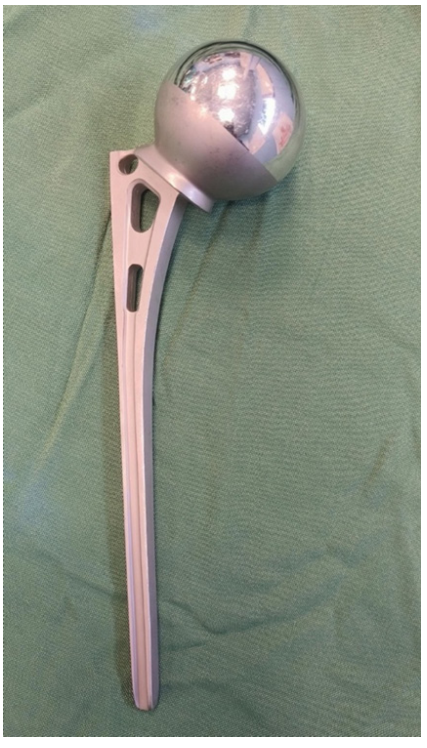

Figure 7 Austin Moore Prosthesis

Figure 8 Thompson's Prosthesis

Conflict of Interest

None

References

1. Gu Y, Yingqi C, Li W, Cheng N, Deng S, Ma Y, et al. Geotemporal disparities in hip fractures burden among individuals aged≥ 55 years (1990-2021) with projections to 2050. Front Public Heal. 2025;13:1600452. https://doi.org/10.3389/fpubh.2025.1600452

2. Sale JEM, Beaton D, Bogoch E. Secondary prevention after an osteoporosis-related fracture: an overview. Clin Geriatr Med. 2014;30(2):317-32. https://doi.org/10.1016/j.cger.2014.01.009

3. Naureen G, Johansson H, Iqbal R, Jafri L, Khan AH, Umer M, et al. A surrogate FRAX model for Pakistan. Arch Osteoporos. 2021;16(1):34. https://doi.org/10.1007/s11657-021-00894-w

4. Tabu I, Goh EL, Appelbe D, Parsons N, Lekamwasam S, Lee JK, et al. Service availability and readiness for hip fracture care in low-and middle-income countries in South and Southeast Asia. Bone Jt Open. 2023;4(9):676-81. https://doi.org/10.1302/2633-1462.49.BJO-2023-0075.R1

5. Dhakal S, Sharma K, Adhikari K, Joshi A, Poudyal S. Osteoporosis and its associated factors among patients attending Manakamana Hospital, Chitwan, Nepal. PLoS One. 2024;19(2):e0289517. https://doi.org/10.1371/journal.pone.0289517

6. Parker MJ, Handoll HH, Bhargara A. Conservative versus operative treatment for hip fractures. Cochrane database Syst Rev. 2000;(4):CD000337. https://doi.org/10.1002/14651858.CD000337

7. Choudhry B, Leung B, Filips E, Dhaliwal K. Keeping the traction on in orthopaedics. Cureus. 2020;12(8). https://doi.org/10.7759/cureus.10034

8. Dahl HK. Surgical treatment of femoral neck fractures. The 100-year anniversary. Tidsskr den Nor Laegeforening Tidsskr Prakt Med ny Raekke. 1994;114(30):3600-3.

9. Mei J. A brief history of internal fixation of femoral neck fracture. Zhonghua yi shi za zhi (Beijing, China 1980). 2014;44(2):101-5.

10. Todd RB, Bowman W. The physiological anatomy and physiology of man. Lea and Blanchard; 1850.

11. Colles A. Fracture of the neck of the femur. Dublin Hosp Reports. 1818;2:334-55.

12. Smith RW. Observations on the diagnosis and pathology of fractures of the neck of the femur. Dublin J Med Sci. 1840;18(1):1-70. https://doi.org/10.1007/BF02943065

13. Smith RW. A Treatise on Fractures in the Vicinity of the Joints, and on Certain Forms of Accidental and Congenital Dislocations. Hodges & Smith; 1850. https://doi.org/10.1097/00000441-185001000-00011

14. Leonhardt M. Bernard Rudolph Konrad von Langenbeck (1810-1887). Pathologe. 1988;9(5):322.

15. Cooper A, Travers B. Surgical essays. Vol. 1. Cox; 1818.

16. EARLE H. Surgeon Extraordinary to the Queen. 1815;

17. Earle H. Practical observations in surgery. Underwood; 1823.

18. Walusinski O, Poirier J. Percivall Pott (1713-1788) on the curvature of the spine and the French contribution. Rev Neurol (Paris). 2022;178(7):635-43. https://doi.org/10.1016/j.neurol.2021.08.010

19. Bartonícek J. Proximal femur fractures: the pioneer era of 1818 to 1925. Clin Orthop Relat Res. 2004;419:306-10. https://doi.org/10.1097/00003086-200402000-00047

20. Smith-Petersen MN, Cave EF, Vangorder GW. Intracapsular fractures of the neck of the femur: treatment by internal fixation. Arch Surg. 1931;23(5):715-59. https://doi.org/10.1001/archsurg.1931.01160110002001

21. Thornton L. The treatment of trochanteric fractures of the femur: two new methods. Piedmont Hosp Bull. 1937;10:21-35.

22. McLaughlin HL, Garcia A. An adjustable fixation device for the hip. Am J Surg. 1955;89(4):867-71. https://doi.org/10.1016/0002-9610(55)90155-0

23. Pauwels F. Der schenkelhalsbruch: ein mechanisches Problem. In: Gesammelte Abhandlungen zur funktionellen Anatomie des Bewegungsapparates. Springer; 1935. p. 1-138. https://doi.org/10.1007/978-3-642-86841-2_1

24. McMurray TP. Ununited fractures of the neck of the femur. JBJS. 1936;18(2):319-27.

25. McMurray TB. Oblique Osteotomy for Fracture of Neck of Femur. Br Med J. 1938 Feb;1(4023):330-3. https://doi.org/10.1136/bmj.1.4023.330

26. Shah RK, Sharma DP. Appropriate management of femoral neck fractures in Nepal. Trop Doct. 1991 Oct;21(4):159-61. https://doi.lorg/10.1177/004947559102100408

27. HUDSON OC, BARTELS WP, FREESE CF. End result study of McMurray osteotomy for acute fractures of the femoral neck. Am J Surg. 1951 Feb;81(2):215-20. https://doi.org/10.1016/0002-9610(51)90215-2

28. Bartoníček J, Rammelt S. The history of internal fixation of proximal femur fractures Ernst Pohl-the genius behind. Int Orthop. 2014;38(11):2421-6. https://doi.org/10.1007/s00264-014-2320-3

29. Jewett EL. Rigid internal fixation of intracapsular femoral neck fractures. Am J Surg. 1956;91(4):621-6. https://doi.org/10.1016/0002-9610(56)90295-1

30. Kazár G, Manninger J. Historical retrospection. In: Internal fixation of femoral neck fractures: An atlas. Springer; 2007. p. 85-103. https://doi.org/10.1007/978-3-211-68585-3_4

31. Ender J, Simon-Weidner R. Die Fixierung der trochanteren Brüche mit runden elastischen Condylennägeln. Acta Chir austriaca. 1970;2(1):40-2. https://doi.org/10.1007/BF02600735

32. Andersson S, Herrlin K, Wallöe A, Lidgren L. Complications after trochanteric fractures: A comparison between Ender and nail-plate osteosynthesis. Acta Orthop Scand. 1984;55(2):187-91. https://doi.org/10.3109/17453678408992335

33. Müller ME, Bandi W, Bloch HR, Allgöwer M, Mumenthaler A, Willenegger H, et al. Technique

of internal fixation of fractures. Springer Science & Business Media; 2012.

34. Medoff RJ, Maes K. A new device for the fixation of unstable pertrochanteric fractures of the hip. J Bone Joint Surg Am. 1991 Sep;73(8):1192-9. https://doi.org/10.2106/00004623-199173080-00008

35. Moore AT, Bohlman HR. Metal hip joint. A case report. JBJS. 1943;25(3):688-92.

36. Moore AT. The self-locking metal hip prosthesis. JBJS. 1957;39(4):811-27. https://doi.org/10.2106/00004623-195739040-00005

37. THOMPsoN FR. An essay on the development of arthroplasty of the hip. Clin Orthop Relat Res. 1966;44:73-82. https://doi.org/10.1097/00003086-196601000-00007

38. Thompson FR. Indications and contraindications for the early use of an intramedullary hip prosthesis. Clin Orthop Relat Res. 1955;6:9-16.

39. van der Sijp MPL, van Delft D, Krijnen P, Niggebrugge AHP, Schipper IB. Surgical approaches and hemiarthroplasty outcomes for femoral neck fractures: a meta-analysis. J Arthroplasty. 2018;33(5):1617-27. https://doi.org/10.1016/j.arth.2017.12.029

40. Li X, Luo J. Hemiarthroplasty compared to total hip arthroplasty for the treatment of femoral neck fractures: a systematic review and meta-analysis. J Orthop Surg Res. 2021;16(1):172. https://doi.org/10.1186/s13018-020-02186-4

41. Rang M. The Story of Orthopaedics [Internet]. W.B. Saunders; 2000. Available from: https://books.google.com.np/books?id=3qBsAAAAMAAJ

42. Jones K. Hugh Owen Thomas (1834-1891). In: 100 Notable Names from General Practice. CRC Press; 2018. p. 53-5. https://doi.org/10.1201/9781315152479-17

43. Thomas HO. Diseases of the Hip, Knee and Ankle Joint with Their Deformities Treated by a New and Efficient Method. Clin Orthop Relat Res. 1974;102:4-9. https://doi.org/10.1097/00003086-197407000-00002

44. Danford JR, Stinner DJ. World War I and the Thomas Splint: A Historical Review. Mil Med. 2025;190(1-2):8-11. https://doi.org/10.1093/milmed/usae108

45. Dittel KK, Rapp M. The double dynamic martin screw (DMS): adjustable implant system for proximal and distal femur fractures. Springer Science & Business Media; 2009. https://doi.org/10.1007/978-3-7985-1842-1

46. Bonnaire F, Hellmund R, Lein T. DHS. Trauma und Berufskrankheit. 2003;5(Suppl 2):s162-70. https://doi.org/10.1007/s10039-001-0500-z

47. Lewis KM, Boutelle WE, Roberts MA. Intracapsular Fracture of the Neck of the Femur: Observations on 152 Patients Treated by Internal Fixation with the Smith-Peterson Nail. Ann Surg. 1950;131(3):376. https://doi.org/10.1097/00000658-195003000-00008

48. Charnley J. The treatment of fractures of the neck of the femur by compression. Acta Orthop Scand. 1961;30(1-4):29-48. https://doi.org/10.3109/17453676109149521

49. Charnley J. Long-term results of low-friction arthroplasty. Hip. 1982;42-9.

50. Charnley J. The classic: The bonding of prostheses to bone by cement. 1964. Clin Orthop Relat Res. 2010 Dec;468(12):3149-59. https://doi.org/10.1007/s11999-010-1545-8

51. CHARNLEY J. The walking calliper. Lancet (London, England). 1947 Sep;2(6474):464-7. https://doi.org/10.1016/S0140-6736(47)90475-3

52. Calvert PT. The Gamma nail--a significant advance or a passing fashion? Vol. 74, The Journal of bone and joint surgery. British volume. England; 1992. p. 329-31. https://doi.org/10.1302/0301-620X.74B3.1587869

53. Russell TA, Klima ML. History and Evolution of Hip Design to Decrease Failure. J Orthop Trauma. 2023 Oct;37(10S):S49-54. https://doi.org/10.1097/BOT.0000000000002668

54. Ridha M, Al-Jabri T, Stelzhammer T, Shah Z, Oragui E, Giannoudis P V. Osteosynthesis, hemiarthroplasty, total hip arthroplasty in hip fractures: All I need to know. Injury. 2024 Mar;55(3):111377. https://doi.org/10.1016/j.injury.2024.111377

55. Kennedy IW, Meek RMD. Latest developments in arthroplasty for hip fractures. Bone Joint J. 2024 Dec;106-B(12):1372-6. https://doi.org/10.1302/0301-620X.106B12.BJJ-2024-0338