

# External Fixation is Safe for Damage Control Orthopaedics in a Combat Environment



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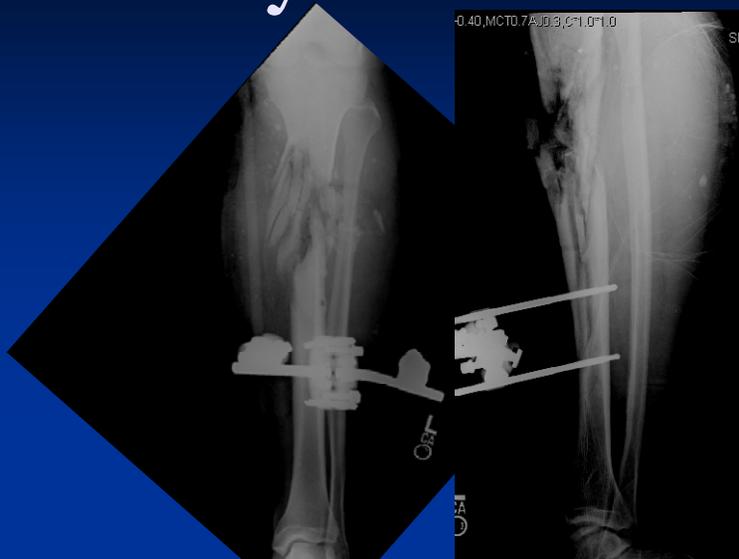
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# Why Use External Fixation in Combat?



- Pain Control
  - Transportation
- Soft-Tissue Stability
  - Vascular bypass graft
- Systemic Benefits
- Stability: ? Infection prevention



Pape HC, Hildebrand F, Pertschy S, et al.  
Changes in the management of femoral shaft fractures in polytrauma patients:  
from early total care to damage control orthopedic surgery.

*The Journal of Trauma* 2002;53:452-461.

The prevention of infection in open fractures: an experimental study of the effect of fracture stability.

Worlock P, Slack R, Harvey L, et al.

*Injury* 1994;25:31-38.



# Challenges: Complex Injuries





# Challenges: Environment

- Facilities
- Poly-trauma
  - Simultaneous procedures
- Limited resources
  - Parts
  - Power
  - C-arm





# Literature Support

Ficke JR, Pollak AN. Extremity War Injuries: Development of Clinical Treatment Principles. *JAAOS* 2007; 15: 590 - 595.

Della Rocca GJ, Crist BD. External fixation versus conversion to intramedullary nailing for definitive management of closed fractures of the femoral and tibial shaft. *JAAOS* 2006;14:S131-135..

Lin DL, Kirk KL, Murphy KP, McHale KA, Doukas WC. Evaluation of orthopaedic injuries in operation enduring freedom. *J Orthop Trauma* 2004, 18:5;300..

Hammer R, Rooser B, Lidman D. Simplified external fixation for primary management of sever musculoskeletal injuries under war and peace time condition. *J Orthop Trauma* 1996, 10;545-554.

Has B, Jovanovic S, Wertheimer B, et al. External fixation as a primary and definitive treatment of open limb fractures. *Injury* 1995, 26, 4;235-248.

Maricevic A. Erceg M. War Injuries to Extremities. *Military Medicine* 1997. , 162, 12:808,

Dubravko H, Zarko R, Tomislav T. External fixation in war trauma management of extremities-experience from the war in croatia. *Journal of Trauma Crit Care* 1994, 37(5);831-834.



# Combat Applications

- 15 constructs
  - 14 patients
- Prospective, observational
- Complications: 13/15 (86.7%)
  - Instability 10/15 (67%)
  - Pin Loosening 5/15 (33%)
  - Pin track infx 3/15 (20%)



Early Failure Of External Fixation In The Management Of War Injuries

JC Clasper, SL Phillips

*J R Army Med Corps 2005; 151: 81-86*



# Methods

- IRB approved, Retrospective Study
- Electronic Records Reviewed
  - Electronic inpatient/outpatient charts
  - Radiographs
  - Operative logs
  - Joint Theater Trauma Registry (JTTR)





# Methods

- Inclusion Criteria
  - Combat injury
  - Type III open tibia fracture
  - March 2003 to September 2007
  - Definitively treated at our institution (BAMC)





# Methods

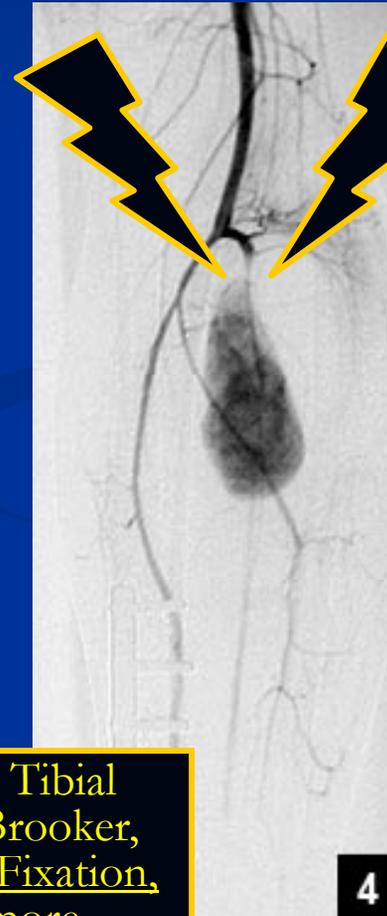
- Stratified Complications
  - Major, Potential, Minor
- “Successful Application”
  - Lack of Major and/or Potential Complications





# Major Complications

## ■ Neurovascular Injury



Burny F. Elastic External Fixation of Tibial Fractures, Study of 1,421 Cases. Brooker, AF Jr. and Edwards CC. : External Fixation, The Current State of Art. Baltimore, Williams and Wilkins, 1979.



# Major Complications

## ■ Pin track osteomyelitis

Green SA. Complications in External Fixation. *Clin Orthop Relat Res.* 1983;180:109-116.

| <i>Author, Year</i>                      | <i>Type of Fixator</i> | <i>No. of Patients</i> | <i>Minor Pin Tract Infection</i> | <i>Major Pin Tract Infection</i> |
|--|------------------------|------------------------|----------------------------------|----------------------------------|
| Griswold and Homes, 1939 <sup>9</sup>    | Pins-in-plaster        | 259                    | 3%                               | 1%                               |
| Stader, 1942 <sup>28</sup>               | Stader                 | 20                     | 15%                              | 5%                               |
| Wilson and Cantwell, 1942 <sup>31</sup>  | Pins-in-plaster        | 89                     | 0%                               | 0%                               |
| Lewis <i>et al.</i> , 1942 <sup>15</sup> | Stader                 | 20                     | 50%                              | 15%                              |
| Mazet, 1943 <sup>18</sup>                | Roger Anderson         | 9                      | 22%                              | 11%                              |
|  | Stader                 | 110                    | 10%                              | 3%                               |
|  | Roger Anderson         | 80                     | 46%                              | 23%                              |
|  | Roger Anderson         | 237                    | 2%                               | 2%                               |
|  | Hoffmann               | 39                     | 21%                              | 21%                              |
|  | Pins-in-plaster        | 75                     | 3%                               | 0%                               |
|  | Pins-in-plaster        | 208                    | 2%                               | 0%                               |
|  | Hoffmann               | 28                     | ?                                | 3.5%                             |
|  | Roger Anderson         | 10                     | 80%                              | 20%                              |
|  | Zimmer                 | 9                      | ?                                | 11%                              |
|  | ASIF; Wayne; Tower     | 12                     | 17%                              | 8%                               |
|  | Hoffmann               | 40                     | 25%                              | 8%                               |
|  | Hoffmann               | 23                     | 43%                              | 8%                               |
|  | Hoffmann               | 43                     | ?                                | 2%                               |
|  | Roger Anderson         | 38                     | 5%                               | 3%                               |
|  | Hoffmann               | 34                     | ?                                | 13%                              |
|  | Hoffmann, pelvic       | 11                     | 18%                              | 0%                               |

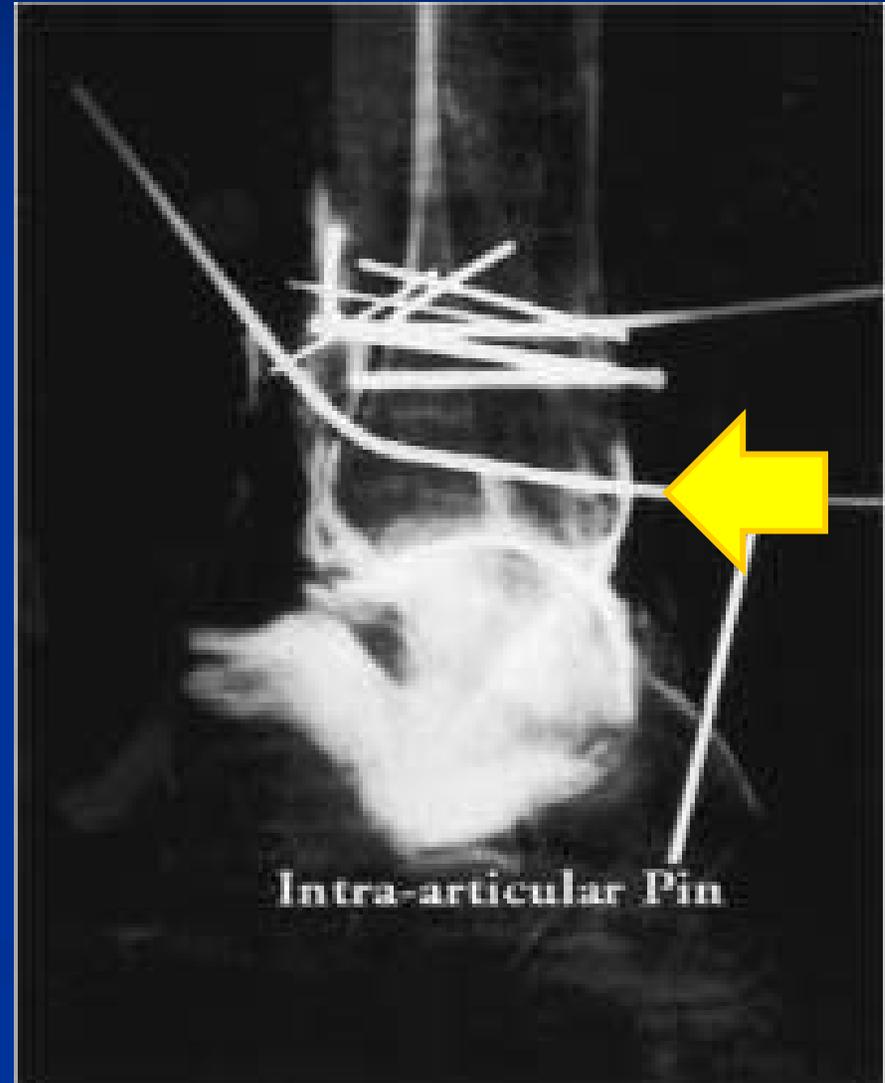




# Major Complications

## ■ Septic Arthritis

Vives M et al. Soft tissue injuries with use of safe corridors for transfixion wire placement during external fixation of distal tibia fractures: An anatomic study. *J Orthopaedic Trauma* Nov 2001 (15)8;555-559.



# Major Complication

- Mechanical Failure





# Potential Complications

- Pins within 1 inch of fracture site

Green, Stuart Alan. Complications of external skeletal fixation causes, prevention and treatment. Springfield, Ill: Thomas, 1981.





# Potential Complications

- Loss of fracture reduction



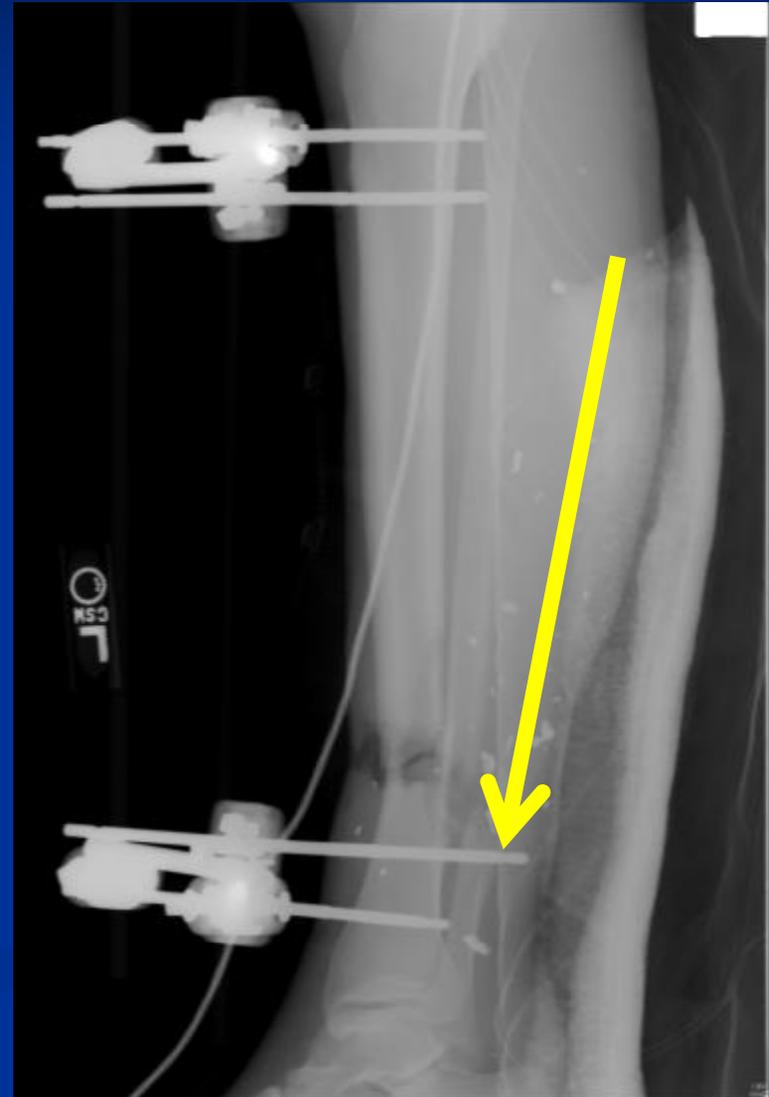
*Clasper J R Army Med Corps 2005*



# Potential Complications

- Deep Pin Over-penetration
  - $\geq 26$  mm

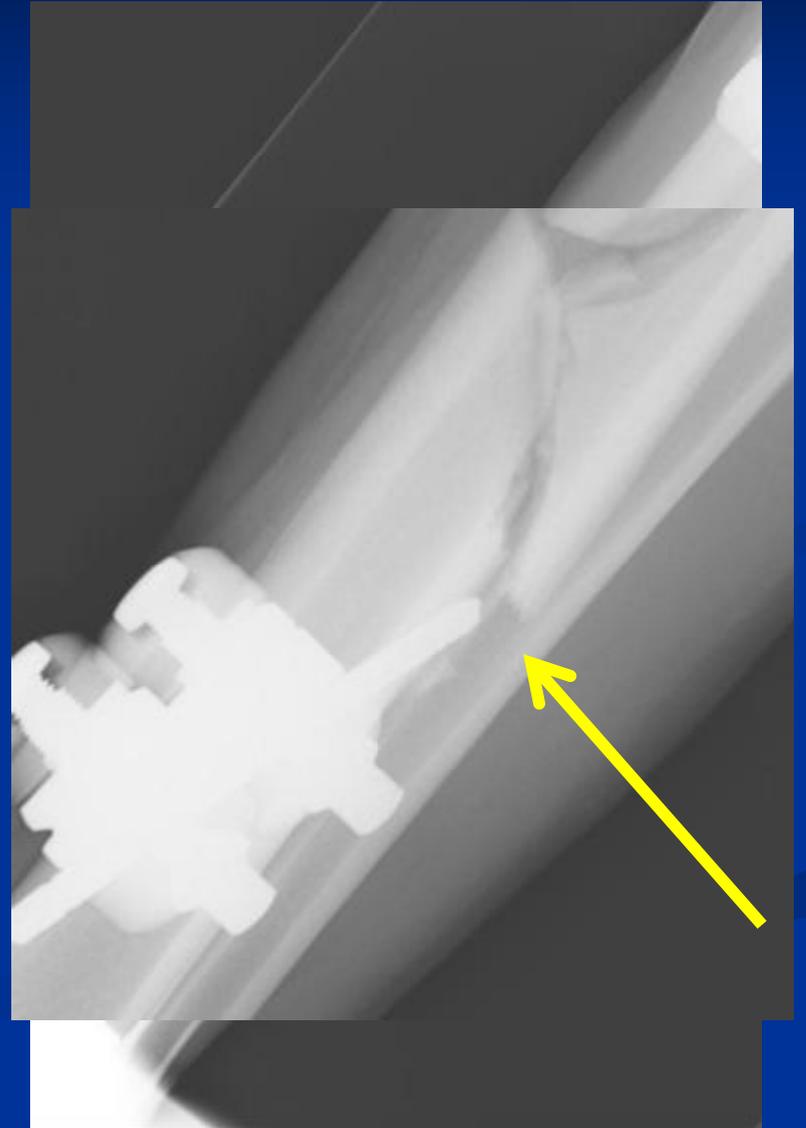
Topp R, et al. The Incidence of Neurovascular Injury during External Fixator Placement Without Radiographic Assistance for Lower Extremity Diaphyseal Fractures: A Cadaveric Study. *J Trauma* 2003;55:955-958.





# Potential Complications

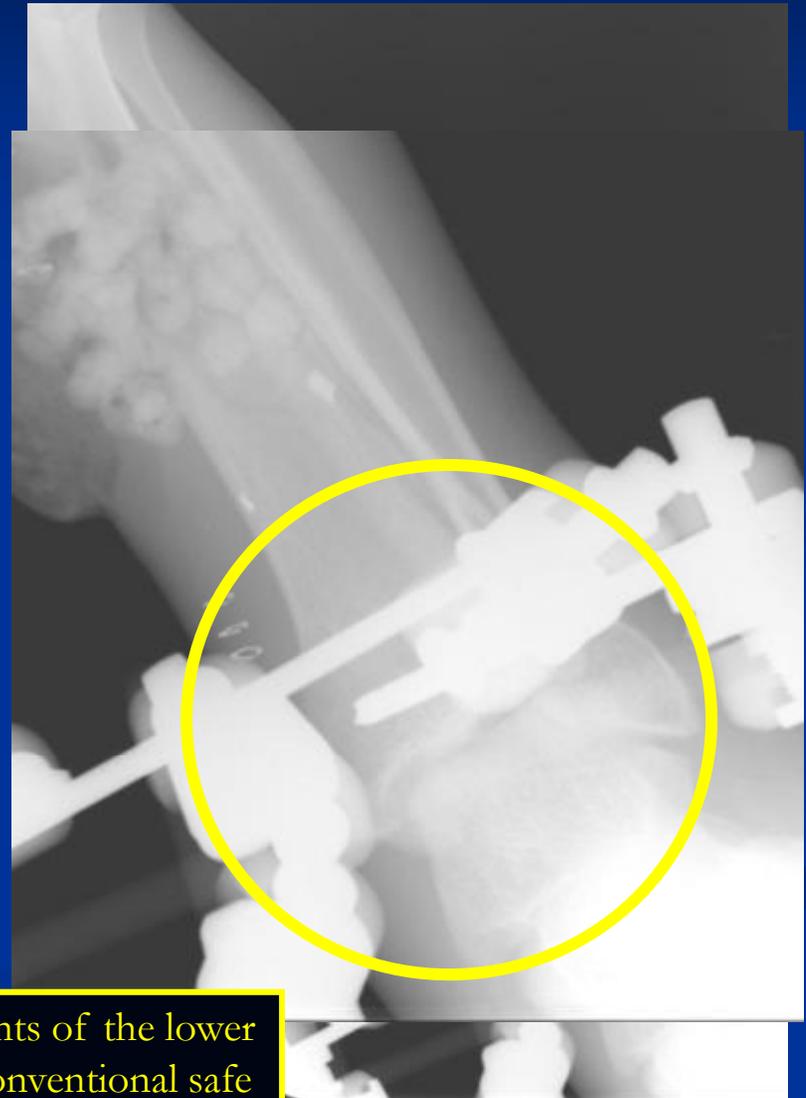
- Soft tissue pin placement
  - No cortical contact





# Potential Complications

- Intra-articular pin placement



P. Stavlasand, D. Polyzois. Septic arthritis of the major joints of the lower limb after periarticular external fixation application: are conventional safe corridors enough to prevent it? *Injury* 2005; 36(2)239-247.



# Minor Complications

## ■ Pin tract infection

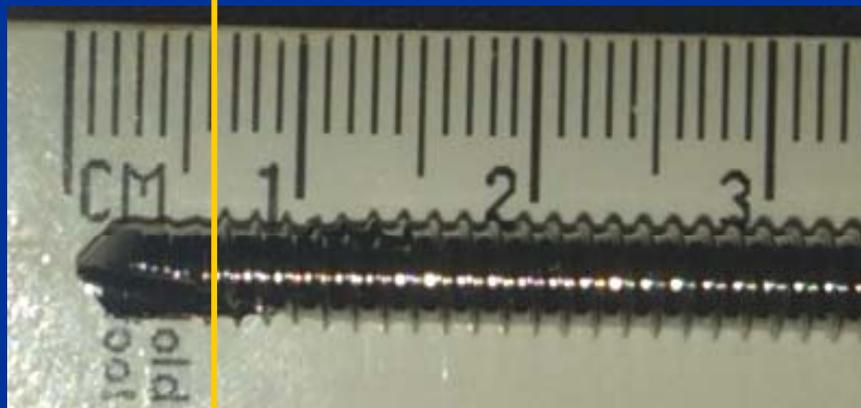
Green SA. Complications in External Fixation. *Clin Orthop Relat Res.* 1983;180:109-116.

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| Shaar <i>et al.</i> , 1944 <sup>26</sup>     | Stader                 | 110                    | 10%                              | 3%                               |
| Siris, 1944 <sup>27</sup>                    | Roger Anderson         | 80                     | 46%                              | 23%                              |
| Naden, 1949 <sup>20</sup>                    | Roger Anderson         | 237                    | 2%                               | 2%                               |
| Fellander, 1963 <sup>7</sup>                 | Hoffmann               | 39                     | 21%                              | 21%                              |
| Scudese <i>et al.</i> , 1970 <sup>25</sup>   | Pins-in-plaster        | 75                     | 3%                               | 0%                               |
| Anderson <i>et al.</i> , 1974 <sup>1</sup>   | Pins-in-plaster        | 208                    | 2%                               | 0%                               |
| Karlström and Olerud, 1975 <sup>12</sup>     | Hoffmann               | 28                     | ?                                | 3.5%                             |
| Chacha, 1974 <sup>4</sup>                    | Roger Anderson         | 10                     | 80%                              | 20%                              |
| Weis <i>et al.</i> , 1976 <sup>29</sup>      | Zimmer                 | 9                      | ?                                | 11%                              |
| Jackson <i>et al.</i> , 1978 <sup>10</sup>   | ASIF; Wayne; Tower     | 12                     | 17%                              | 8%                               |
| Edwards <i>et al.</i> , 1979 <sup>6</sup>    | Hoffmann               | 40                     | 25%                              | 8%                               |
| Krempen <i>et al.</i> , 1979 <sup>13</sup>   | Hoffmann               | 23                     | 43%                              | 8%                               |
| Widenfalk <i>et al.</i> , 1979 <sup>30</sup> | Hoffmann               | 43                     | ?                                | 2%                               |
| Cabanela and Cooney, 1980 <sup>3</sup>       | Roger Anderson         | 38                     | 5%                               | 3%                               |
| Lawyer and Lubbers, 1980 <sup>14</sup>       | Hoffmann               | 34                     | ?                                | 13%                              |
| Mears and Fu, 1980 <sup>19</sup>             | Hoffmann, pelvic       | 11                     | 18%                              | 0%                               |



# Minor Complications

- Pin over penetration between 9 and 25 mm



6 mm



Topp R, et al. The Incidence of Neurovascular Injury during External Fixator Placement Without Radiographic Assistance for Lower Extremity Diaphyseal Fractures: A Cadaveric Study. *J Trauma* 2003;55:955-958.



# Minor Complications

- Instability of the frame requiring addition of a bar or pin



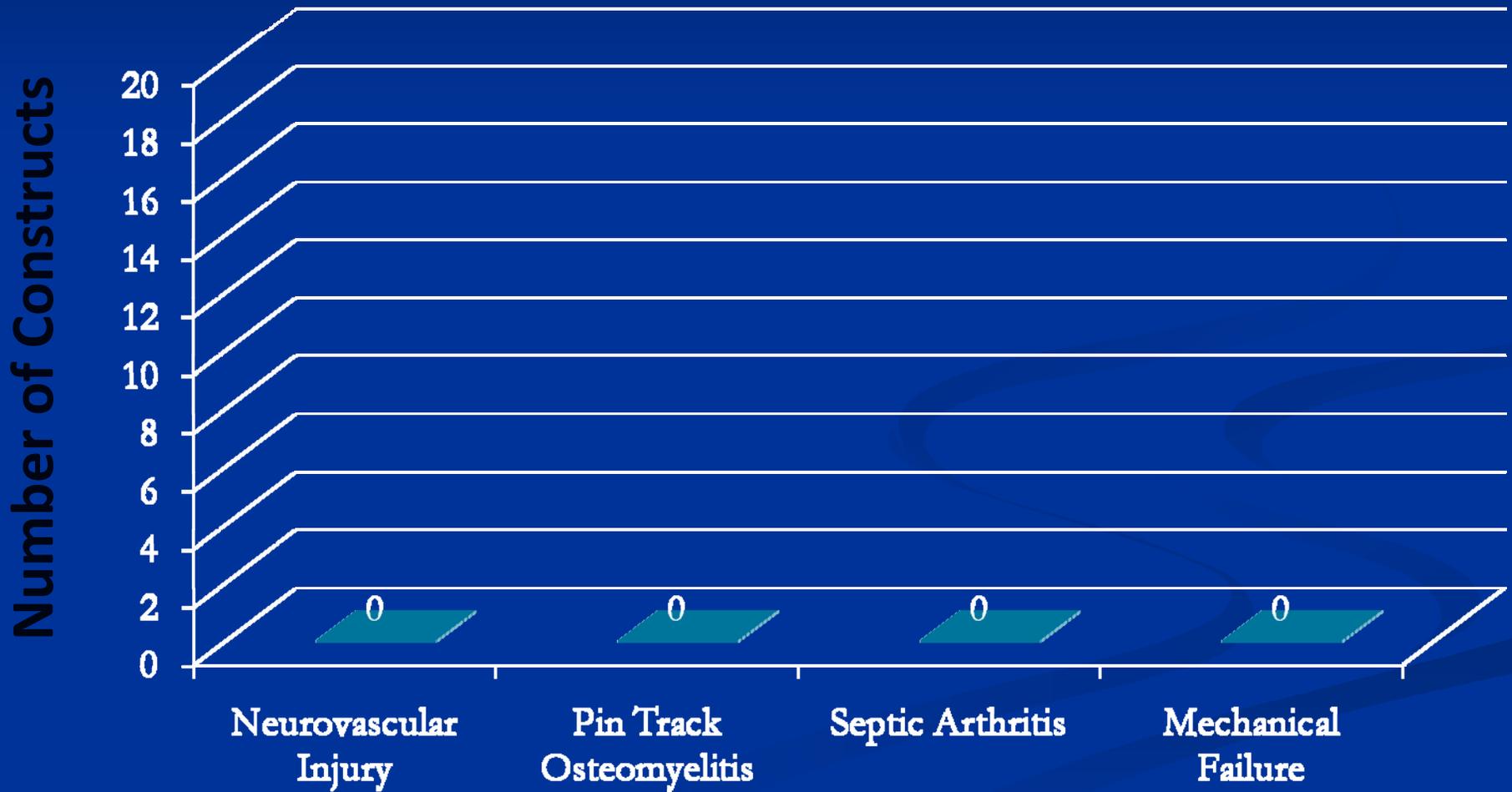


# Results: Demographics

- 43 patients, 53 type III open tibias included
- 91% male, 9% female
- Average Age: 27 years (19-45)
- Injury Severity Score: 17 (9-43)
- Time in External Fixation: 30 days (5-135)
- Average follow up: 2.2 years (8 mo – 5 yrs)



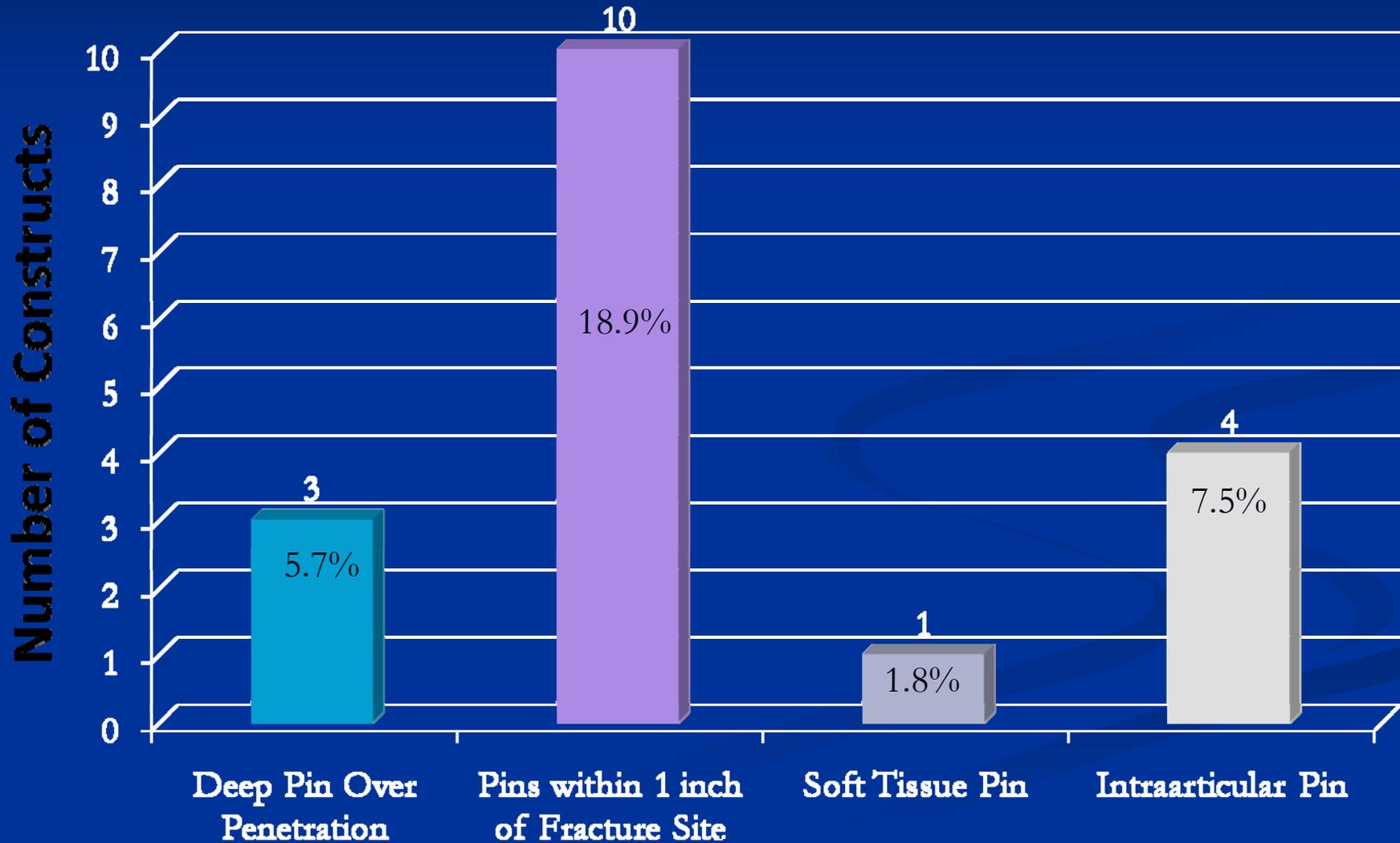
# Major Complications (Total constructs = 53)





# Potential Complications

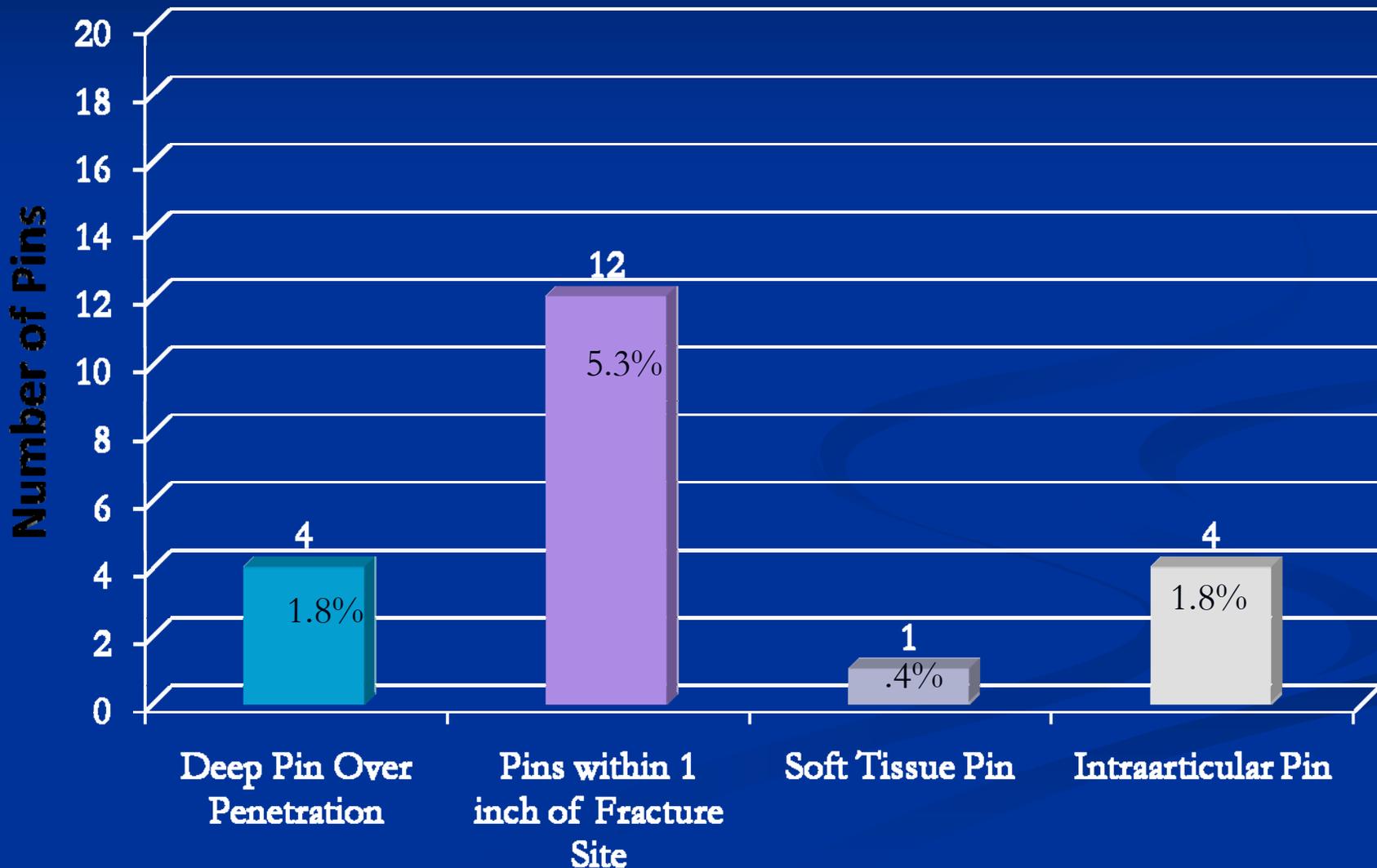
(Total constructs = 53)





# Potential Complications

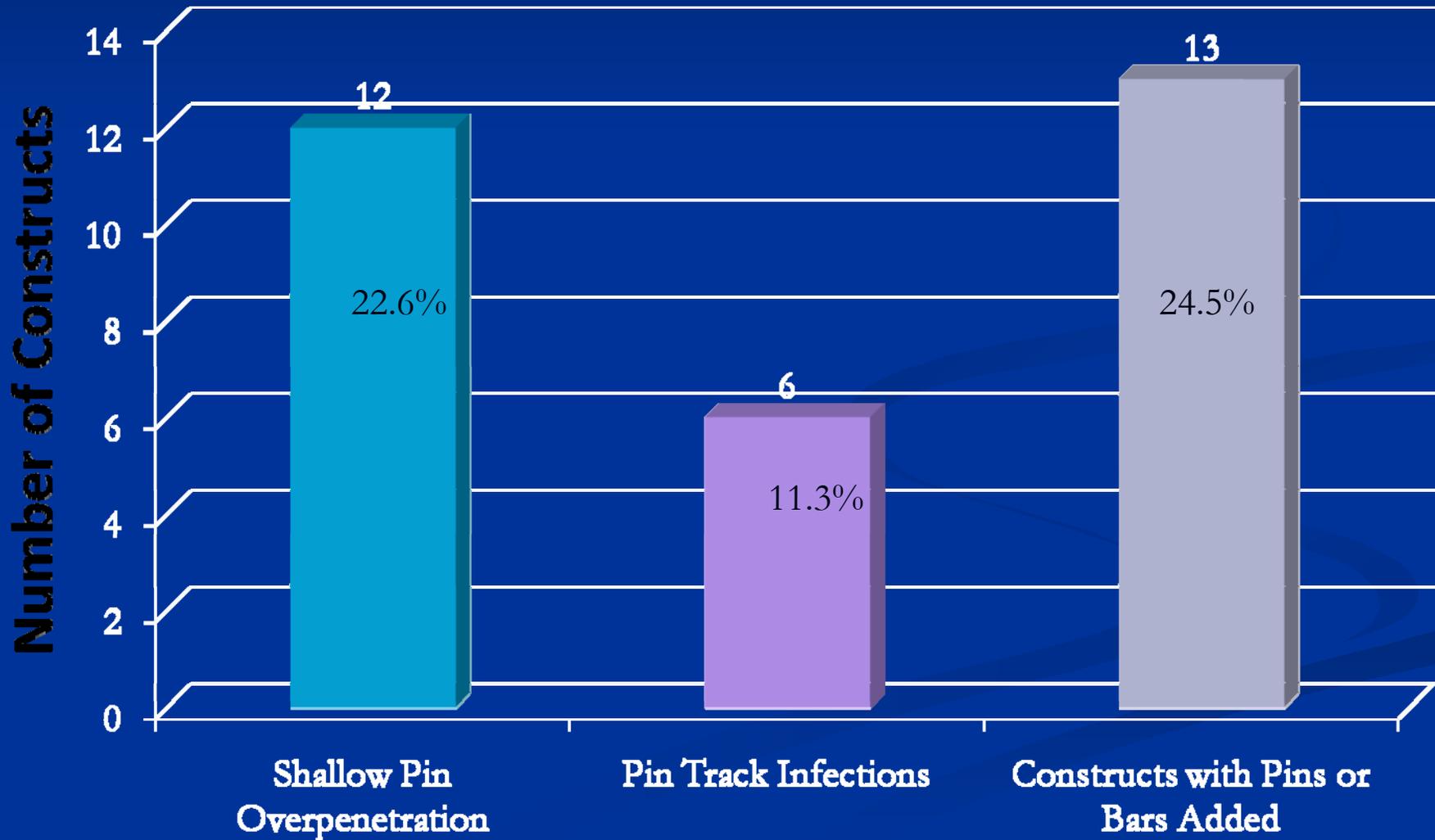
(Total pins = 228)





# Minor Complications

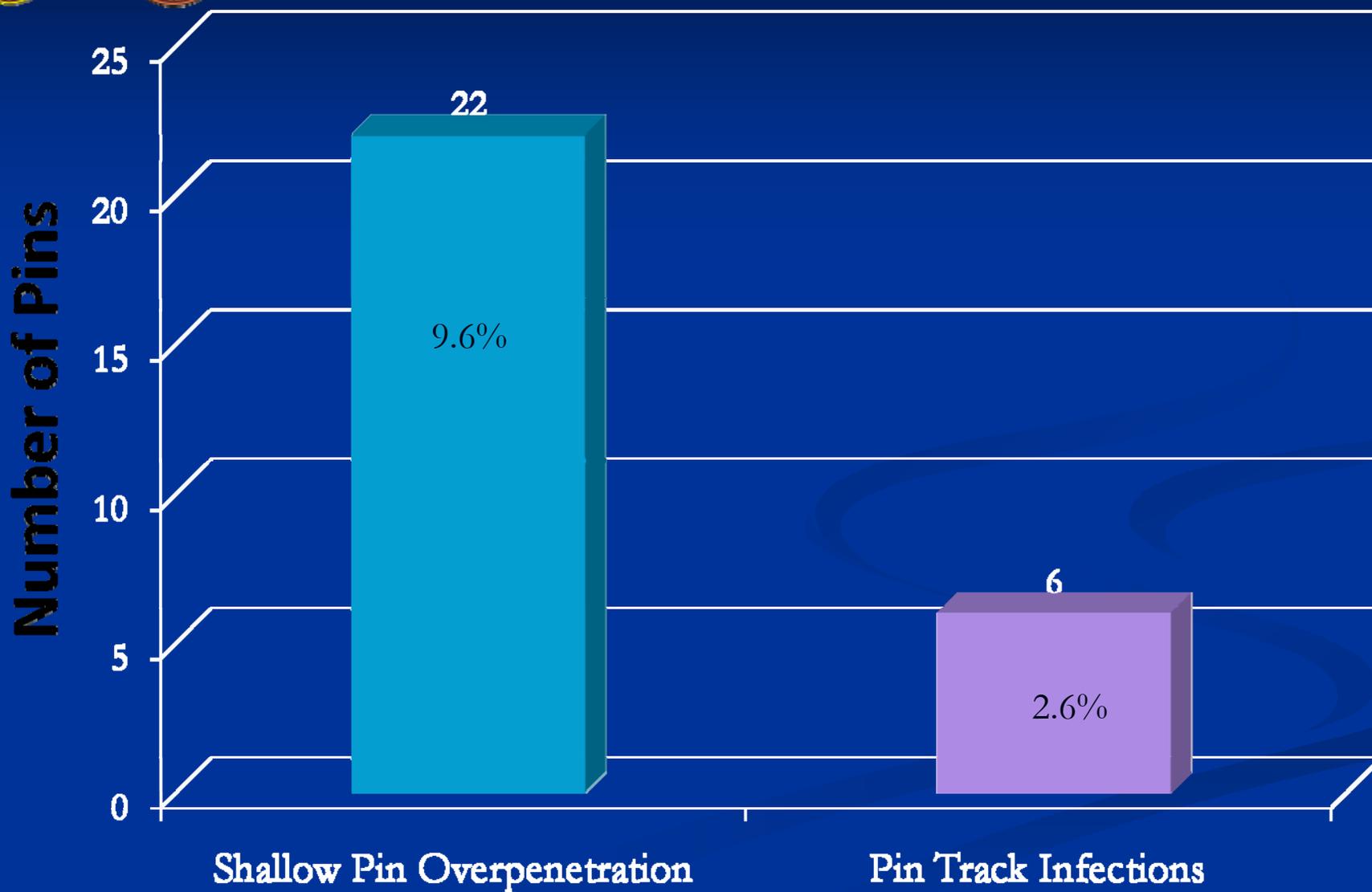
(Total constructs = 53)





# Minor Complications

(Total pins = 228)





# Statistical Analysis

| <i>Variable 1</i>    | <i>Variable 2</i>                   | <i>p value</i> |
|----------------------|-------------------------------------|----------------|
| Location of Fracture | Presence of minor complications     | 0.195          |
|                      | Presence of potential complications | 0.714          |
| G & A Classification | Presence of minor complications     | 0.398          |
|                      | Presence of potential complications | 0.86           |
| OTA Classification   | Presence of minor complications     | 0.79           |
|                      | Presence of potential complications | 0.53           |



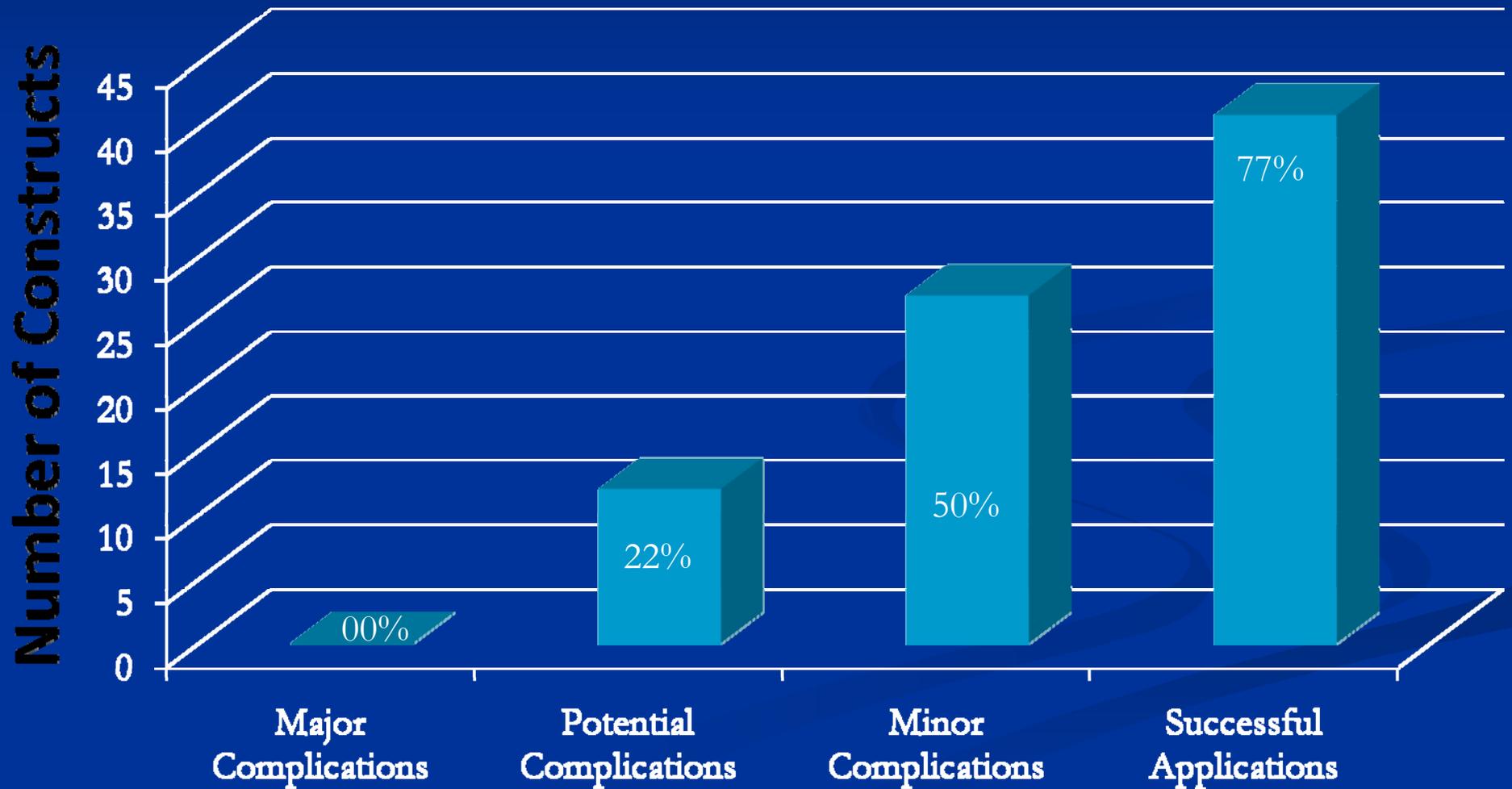
# Statistical Analysis

| <i>Variable 1</i> | <i>Variable 2</i>                   | <i>p value</i> |
|-------------------|-------------------------------------|----------------|
| Osteomyelitis     | Presence of minor complications     | 0.075          |
|                   | Presence of potential complications | 0.775          |
| Deep Infection    | Presence of minor complications     | 0.659          |
|                   | Presence of potential complications | 0.513          |



# Complications Summary

(Total constructs = 53)





# Discussion



- “Successful Application” in 77%
- Technical Improvement Possible in  $> 1/5$



# Conclusion

- External Fixation is Safe for Damage Control Orthopaedics in a Combat Environment

# Questions?

