

Abstract

Wheelchair footrest durability is important for the long-term safety and health of users. Depending on the patient, standard equipment may be upgraded to support unique musculoskeletal needs. However, challenges often arise due to the complexity that follows increased adjustability. The footrest components can experience wear or even complete failure due to the significant and repeated forces that occur in users who retain muscular strength but lack control. For this project, wheelchair footrests were designed which feature reinforcements to the frame, a novel locking mechanism, and decreased joint complexity in order to increase durability.

Background

Client

- Andrea Gehling- Avenues to Community Support Broker
- Mark Hindle- user, 32 y.o. male
 - Cerebral palsy and an intellectual disability
 - Experiences muscle spasticity and seizures
 - Uses wheelchair for transport
- Chris Hindle- guardian

Current Devices

- Quickie® Iris SE Manual Tilt-in-Space Wheelchair
- 70 degree swing in/out footrests
 - Adjustable for length and footplate angle
 - Compressed gas springs

Footrest Failure

- Wear and failure of locking mechanism
- Bolt shearing
- Extension bar torsion



Figure 2. Chipped pin.



Figure 1. Current footrests.



Figure 3. Worn locking mechanism.

Design Criteria

- Safe and comfortable for user
- Fit existing wheelchair and be able to be transferred to future chairs
- Must swing away to accommodate lift
- Removable for transport
- Able to be manipulated by single caregiver
- Must be similar weight to current footrests, no more than 15 lbs
- Survive applied forces by Mark- up to 3000 N
- Within budget of \$200 dollars

Final Design

“Extended Hanger”

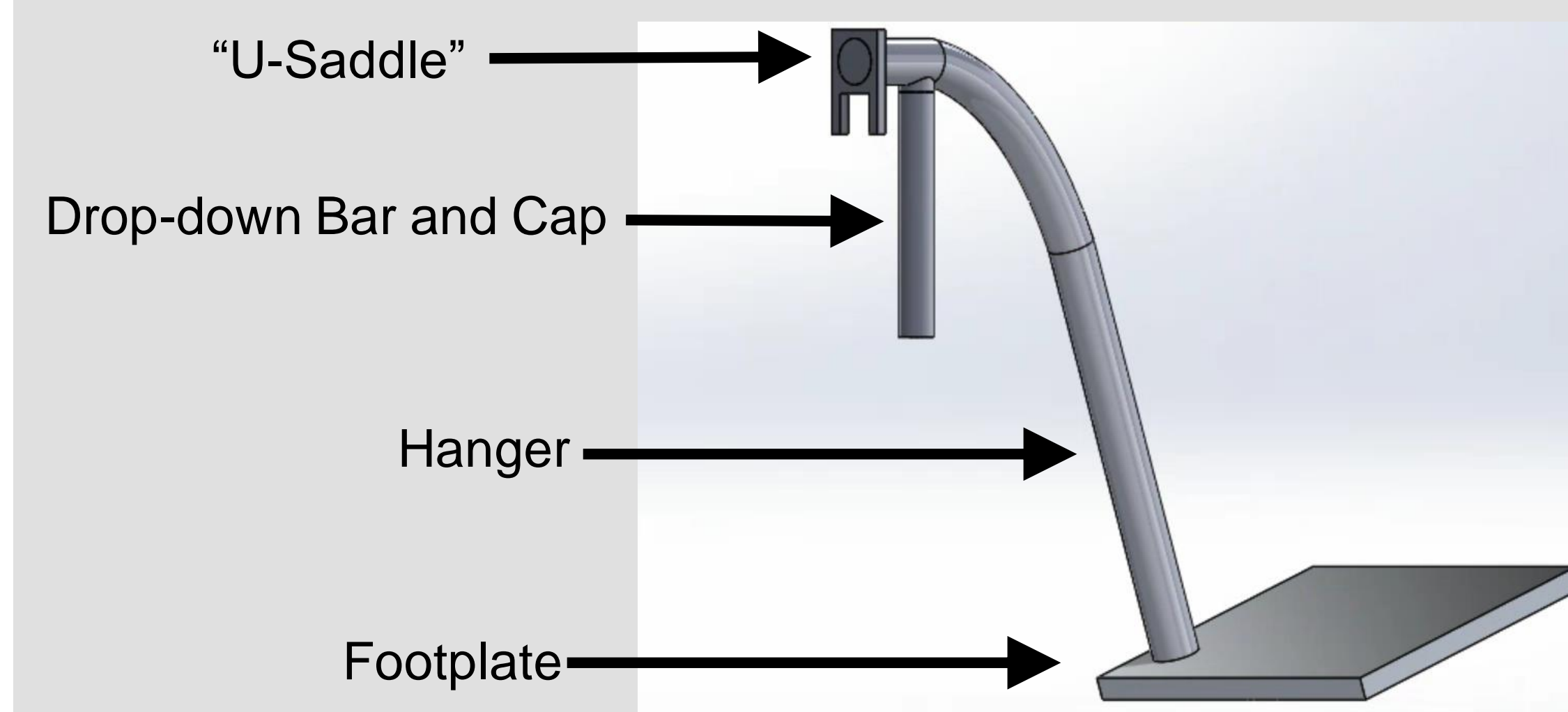


Figure 4. Extended Hanger footrest.

Design Features

- Single pronged hanger- 2024 aluminum rod
- Aluminum drop-down bar and cap
- “U-saddle”- aluminum plating
 - Prevents rotational movement
 - Point of contact further away from applied load
- TIG welded connections

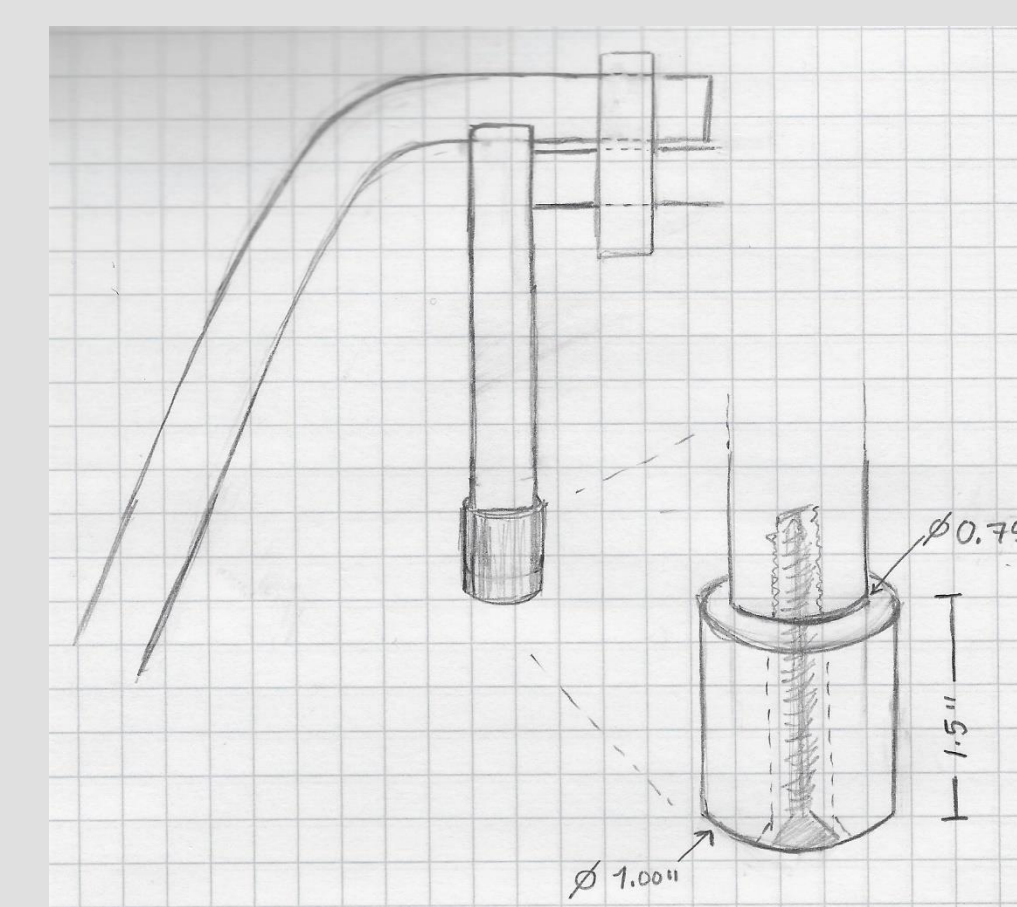


Figure 5. Drop-down bar and cap.

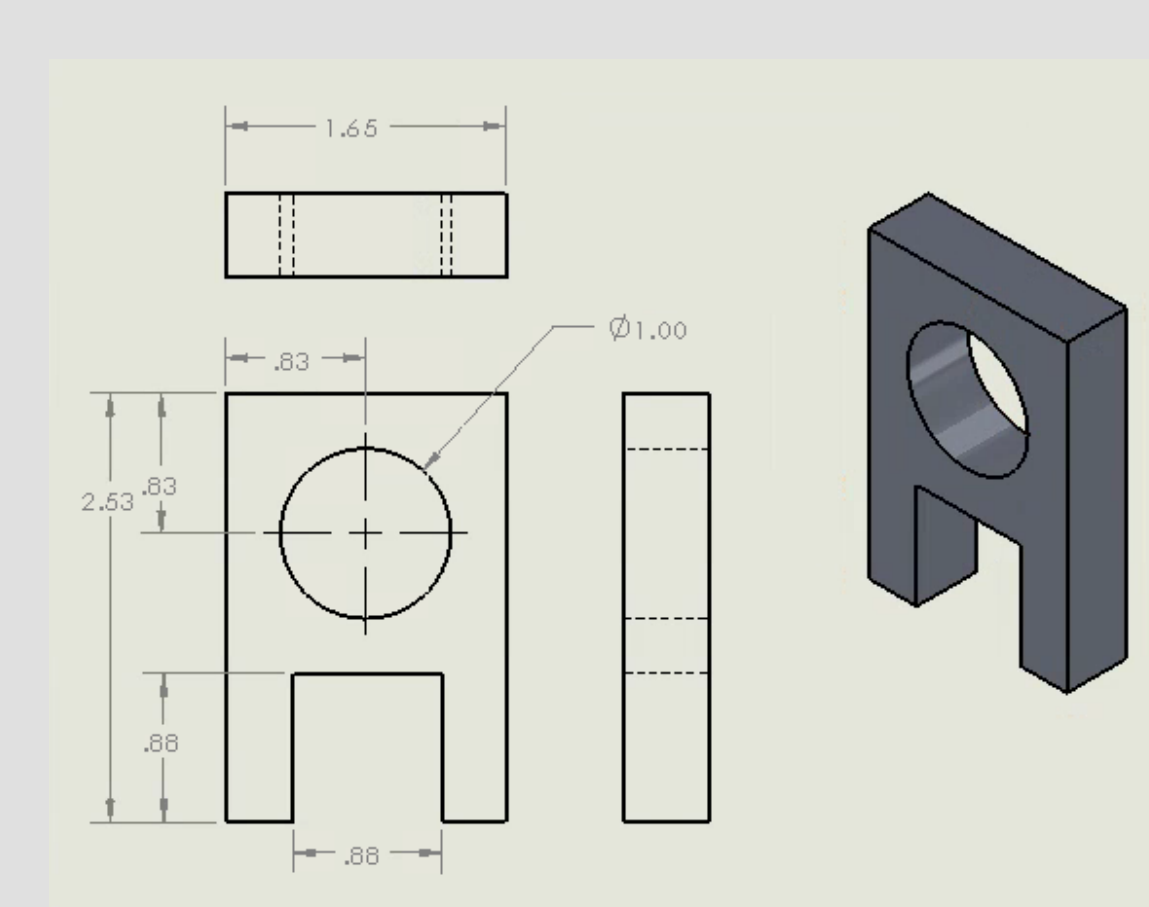


Figure 6. “U-Saddle”.

Design Assessment

Static Calculations

Reduction in forces felt by load bearing components compared to geometry of original footrests by a factor of 3.8.

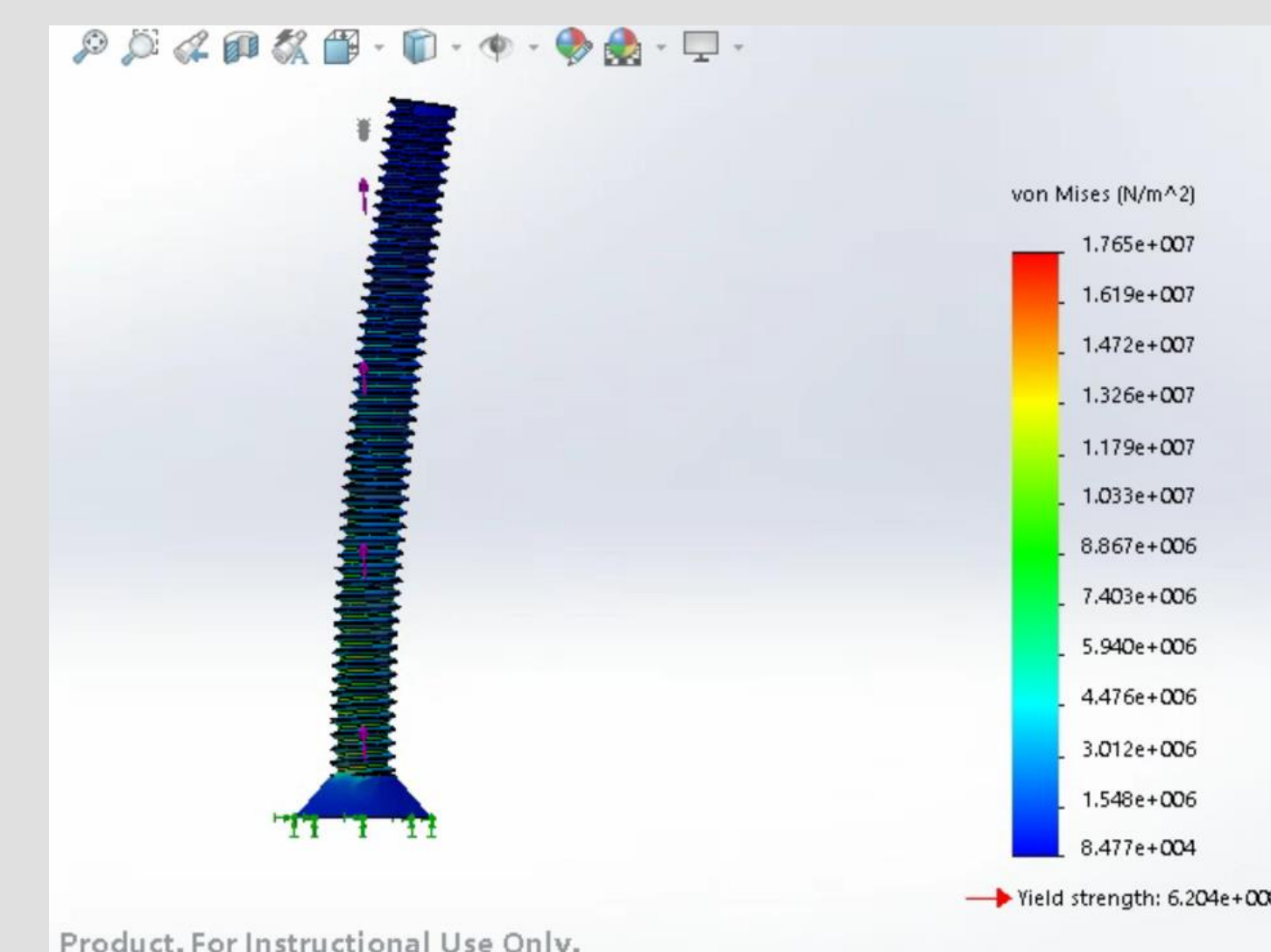


Figure 7. Static test of screw.

SOLIDWORKS Simulation Testing

- Fatigue evaluation: aluminum rod vs. tube
- Weld strength: U-saddle and hanger; hanger and drop-down bar; hanger and footplate
- Static forces applied to: U-saddle, cap, screw



Figure 8. Aluminum rod deformation test.

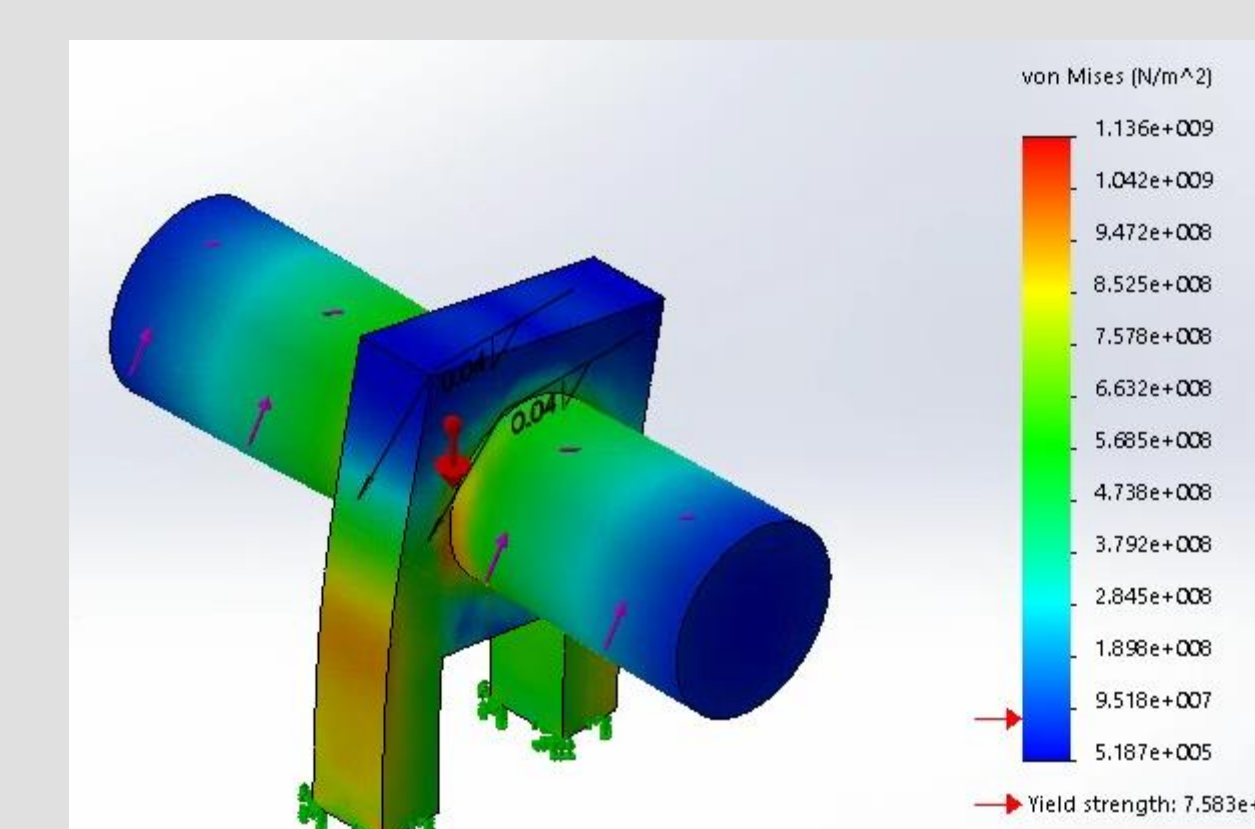


Figure 9. Test of U-saddle weld under applied torque.

None of the components failed or experienced significant deformation under physiologically scaled forces.

Summary

- Simplified design
 - Eliminated locking mechanism, extension bar
 - Removed bolt connections, replaced with weld
- Durable materials
 - Welded aluminum rod
 - Replaceable ¼ 20 x 2.5 stainless steel screw

Future Work

Testing

- Ensure fit with current wheelchair
- Test ease of rotation and removal by single caregiver
- Physiologically accurate fatigue testing of key areas and assembly
- Evaluate success of weld strength

Fabrication

- Add pin to U-saddle to further reduce stress on cap
- Transplant foot cradle and straps from old footrest or fashion new straps
- Fabricate second footrest based on client feedback

References

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