Wearable Sleeve for Growth Modulation Monitoring

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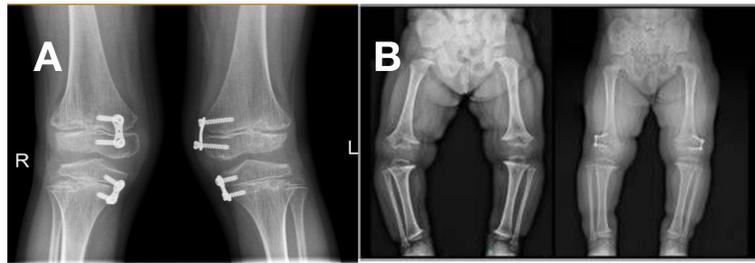
Background

Fig 1. X-ray images of patients with knocked knees with implants (A) and bowed knees without implants (B).

Genu Valgum and Genu Varum (known as knocked and bowed knees) are conditions in which the knees angle inward and outward, respectively. They require surgical implants to correct knee alignment in a procedure known as growth modulation surgery. Follow-up procedures include X-ray imaging to assess bone correction, requiring frequent in-person visits to orthopedic surgical specialists. As a result, around 15% of patients miss post-surgical implant removal, citing high costs, issues with transportation for patients in rural areas, and an unawareness of the importance of implant removal. This leads to overcorrection and further complications.

Mission Statement

Jointelligence aims to lower patient input dependence by developing non-invasive methods to monitor real time bone growth that can alert professionals and assess the efficacy of the 8-Plate implant in proper knee alignment.
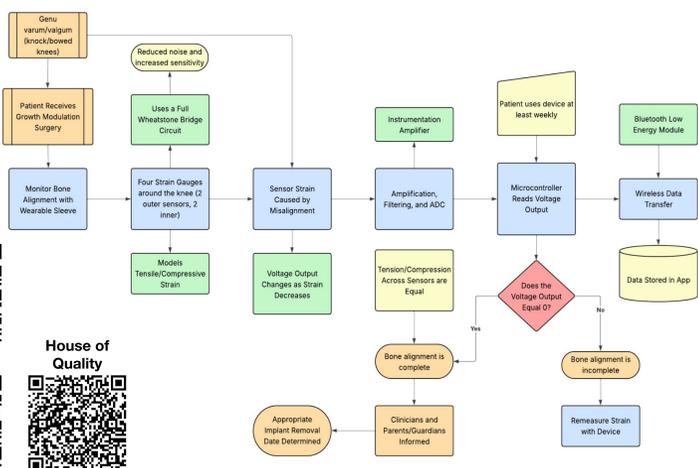
Product Architecture

Fig 2. Product architecture showing the dataflow and process of collecting and sending patient alignment data for monitoring growth modulation post-surgery.
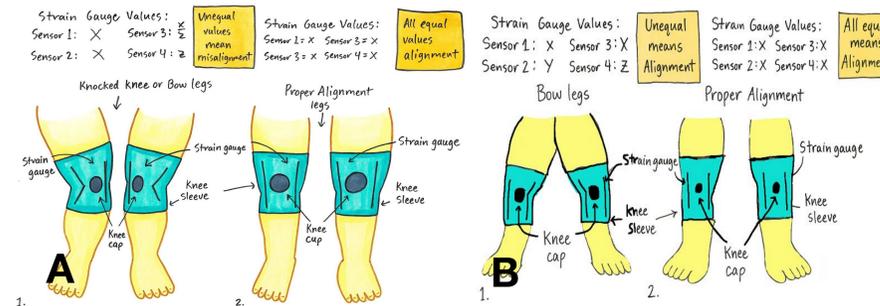
Design Concept

Fig 3. Diagrams showing the applied strain on the sensors due to knee misalignment for both knocked knees (A) and bowed knees (B). With the Wheatstone bridge design, system output is zero (0 V) when all strains are equal. This occurs once the leg is properly aligned.

Fig 4. CAD rendering (Fusion 360) of the knee sleeve device with the attached monitoring system (microcontroller, battery, Bluetooth Low Energy module). Not pictured are the strain gauges that are planned to be implemented straight into the sleeve fabric.
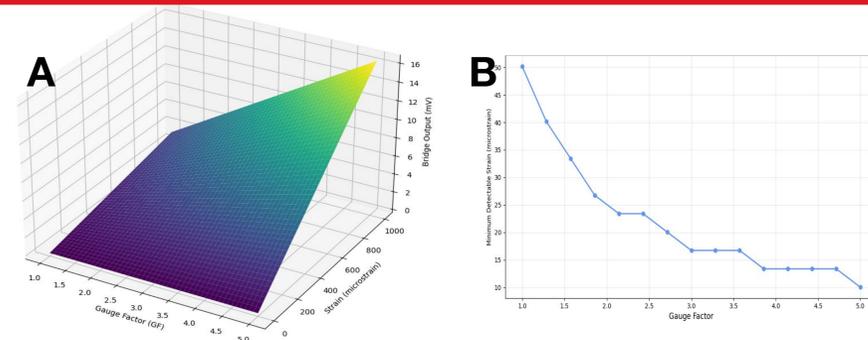
Technical Models

Fig 5. (A) Python generated 3D plot testing both strain gauge factor (GF) and a range of strain detected on the voltage output before digitization, with higher voltages indicating further sensitivity to small strain. (B) Graph showing minimum detectable strain from a digitized voltage output along a value of usable strain gauge factors.

Final Product Specifications

Specification	Target Value
Strain Gauge Factor (GF)	5
Sampling Rate	Weekly (at minimum)
Battery Life	>20 hours
Size	Standardized sizings (S, M, L, etc.)

Table 1. Product specifications to ensure a user-friendly, cost-effective, and accurate method of monitoring bone alignment.

Cost to Manufacture

Component	Price ($)
Knee Sleeve	$5+
Stretch/Strain Gauge	4 X $23 = $92
Microcontroller	$26.50
Battery	$5
Total	$128.50

Table 2. Manufacturing costs of the planned prototype and the necessary components after balancing costs with quality.

Future Directions

- Refining technical models with applicable parameters to establish calibration models.
- Research into implementing sensors and wires embedded in fabric.
- Obtain materials and begin physical prototyping and testing.

Acknowledgements