



**Deploying Artificial Intelligence
and
System Based Technology
for Personalized Spinal Care**

**Pioneer and
Worldwide
Leader for
Personalized
Spinal Care**

**JPMORGAN HEALTH CONFERENCE
SAN FRANCISCO**

January 7-9, 2019

SAFE HARBOR

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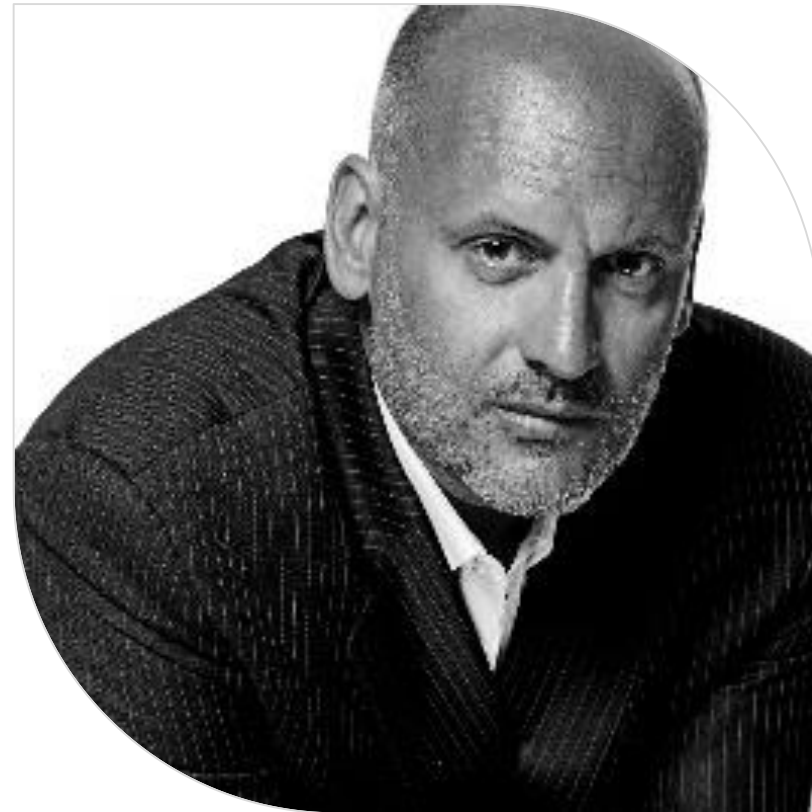
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LEADERSHIP



Denys SOURNAC
Founder, Chairman & CEO

Successful entrepreneur in the medical supply, orthopaedics industry, veterinary pharma with over 30 years' experience creating, building and managing companies.



Joseph Walland
CEO – Medicea USA

Over 15 years' commercial leadership experience in spine, most recently with Stryker Spine.



Richard Washburn
EVP - UNiD ASI

Over 20 years experience in new product development, operations, and medical device commercialization.



Pierre OLIVIER
EVP – B.D and Strategy

Over 25 years' experience in General management, mainly in the United States, particularly in launches of new innovative products.



New York,
 USA



Fabrice KILFIGER
Chief Financial Officer

Over 25 years' experience in finance, including over 15 years heading the finance divisions of listed companies.



David RYAN
Chief Operating Officer

Biomechanical Engineer with more than 11 years' experience in orthopedics. Former R&D Director, Scient'x (Alphatec Spine).



Thomas MOSNIER
Chief Scientific Officer

PhD with over 15 years' experience in spinal research beginning at the Biomechanics Laboratory of ENSAM



Lyon,
 FRANCE



- **UNID ASI: INNOVATIVE SOFTWARE-DRIVEN, SERVICE-ORIENTED APPROACH TO COMPLEX SPINE**
- **FIRST-TO- MARKET PATIENT-SPECIFIC IMPLANTS FOR THE SPINE WITH UNID™ RODS (2013)**
- **FDA CLEARANCE (NOV 2014) AND US LAUNCH OF UNID RODS (2015)**
- **UNID HUB SOFTWARE RELEASED (NASS 2017)**
- **3D-PRINTED PATIENT-SPECIFIC PLATFORM (2018)**
- HEADQUARTERS AND MANUFACTURING FACILITIES IN LYON, FRANCE
- US HEADQUARTERS IN NEW YORK CITY
- 200 EMPLOYEES WORLDWIDE INCLUDING 40 IN THE USA
- 2018 REVENUE PROJECTION OF \$37M, WITH \$20M FROM US MARKET
- PUBLICLY TRADED IN THE USA ON OTCQX: **MRNTF** (SEPT 2018)
- PUBLICLY TRADED IN FRANCE ON EURONEXT GROWTH: **ALMED** (JUNE 2006)



U.S. MARKET OPPORTUNITY

ANNUAL COMPLEX SPINE MARKET (3+ LEVELS)^{1,2}

\$3.48 B

116,000 ANNUAL COMPLEX SPINE CASES¹

\$30,000 AVG REVENUE PER COMPLEX CASE

ANNUAL DEGEN MARKET (1-2 LEVELS)^{1,3}

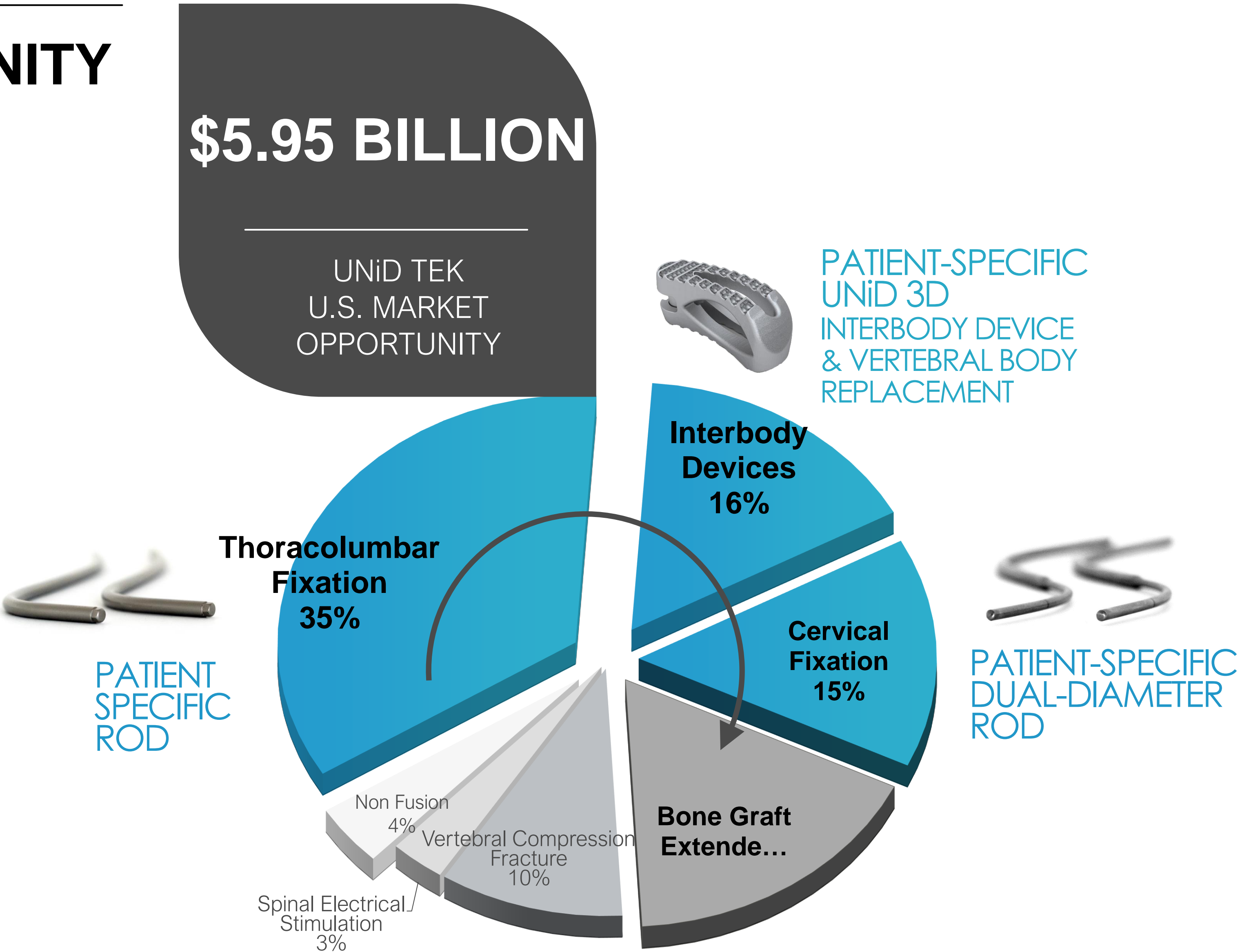
\$2.47 B

221,000 ANNUAL DEGEN CASES¹

\$11,200 AVG REVENUE PER DEGEN CASE

\$5.95 BILLION

UNID TEK U.S. MARKET OPPORTUNITY



1. 2015 Instrumented Thoracolumbar Procedures annually (409,100). 2013 Millennium Research Group, Inc., Table 87 "Thoracolumbar Fusions, by Indication."
 2. \$26,000 per case. Medicea estimated implant and BGE revenues per complex spine procedure.
 3. \$7,370 per case. Medicea estimated implant and BGE revenues per 1-2 level degen procedure.

CURRENT SPINE INDUSTRY IMPLANT CENTRIC MODEL



Outdated Value Proposition

- Commoditization of implants
- Healthcare shift to value and patient outcomes
- High Cost of Sales and inventory requirements

Outdated Implant Solutions

- Rods must be bent manually during surgery
- Interbody selection via trial & error during surgery
- <10% of screws shipped and sterilized are implanted during surgery.

CLINICAL ISSUES

62%

of patients are malaligned post-op¹

63%

of revisions due to inadequate lumbar lordosis⁴

Sagittal Malalignment

15%

of manually bent rods fracture³

24%

fracture-rate with PSO³

Rod Fracture

10X

increased risk of Adjacent Level Disease²

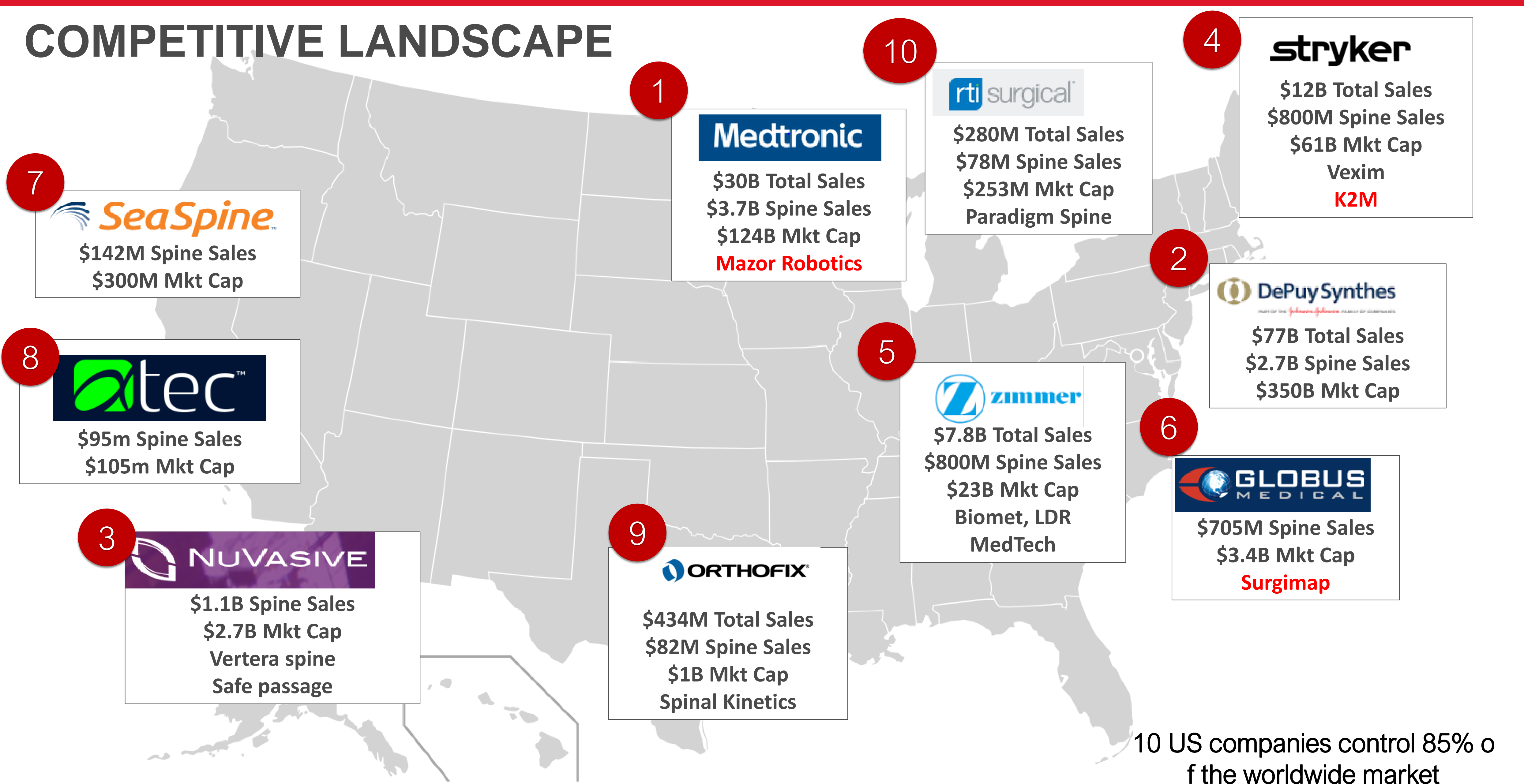
Adjacent Disease

CURRENT TREATMENT METHODS FAIL TO ACHIEVE QUALITY OUTCOMES

- High revision rates
- High levels of adjacent disease
- Increased cost to all stakeholders
- Legal liability issues

1. Moal B, Schwab F, Ames CP, et al. Radiographic Outcomes of Adult Spinal Deformity Correction: A Critical Analysis of Variability and Failures Across Deformity Patterns. Spine Deform. 2014.
2. Rothenfluh DA, Mueller DA, et al. Pelvic incidence-lumbar lordosis mismatch predisposes to adjacent segment disease after lumbar spinal fusion. Eur Spine J (2015) 24:1251-1258
3. Smith JS, Shaffrey CI, Klineberg E, et al. Prospective multicenter assessment of risk factors for rod fracture following surgery for adult spinal deformity. J Neurosurg Spine 21:994-1003, 2014.
4. Jang J-S, Lee S-H, Min J-H, Kim SK, Han K-M, Maeng DH. Surgical treatment outcome of failed back surgery syndrome due to sagittal imbalance. Spine (Phila. Pa. 1976). 2007

COMPETITIVE LANDSCAPE



1

Medtronic
 \$30B Total Sales
 \$3.7B Spine Sales
 \$124B Mkt Cap
Mazor Robotics

10

rti surgical
 \$280M Total Sales
 \$78M Spine Sales
 \$253M Mkt Cap
 Paradigm Spine

4

stryker
 \$12B Total Sales
 \$800M Spine Sales
 \$61B Mkt Cap
 Vexim
K2M

2

DePuySynthes
part of the Johnson & Johnson family of companies
 \$77B Total Sales
 \$2.7B Spine Sales
 \$350B Mkt Cap

5

zimmer
 \$7.8B Total Sales
 \$800M Spine Sales
 \$23B Mkt Cap
 Biomet, LDR
 MedTech

6

GLOBUS MEDICAL
 \$705M Spine Sales
 \$3.4B Mkt Cap
Surgimap

7

SeaSpine
 \$142M Spine Sales
 \$300M Mkt Cap

8

atec
 \$95m Spine Sales
 \$105m Mkt Cap

3

NUVASIVE
 \$1.1B Spine Sales
 \$2.7B Mkt Cap
 Vertera spine
 Safe passage

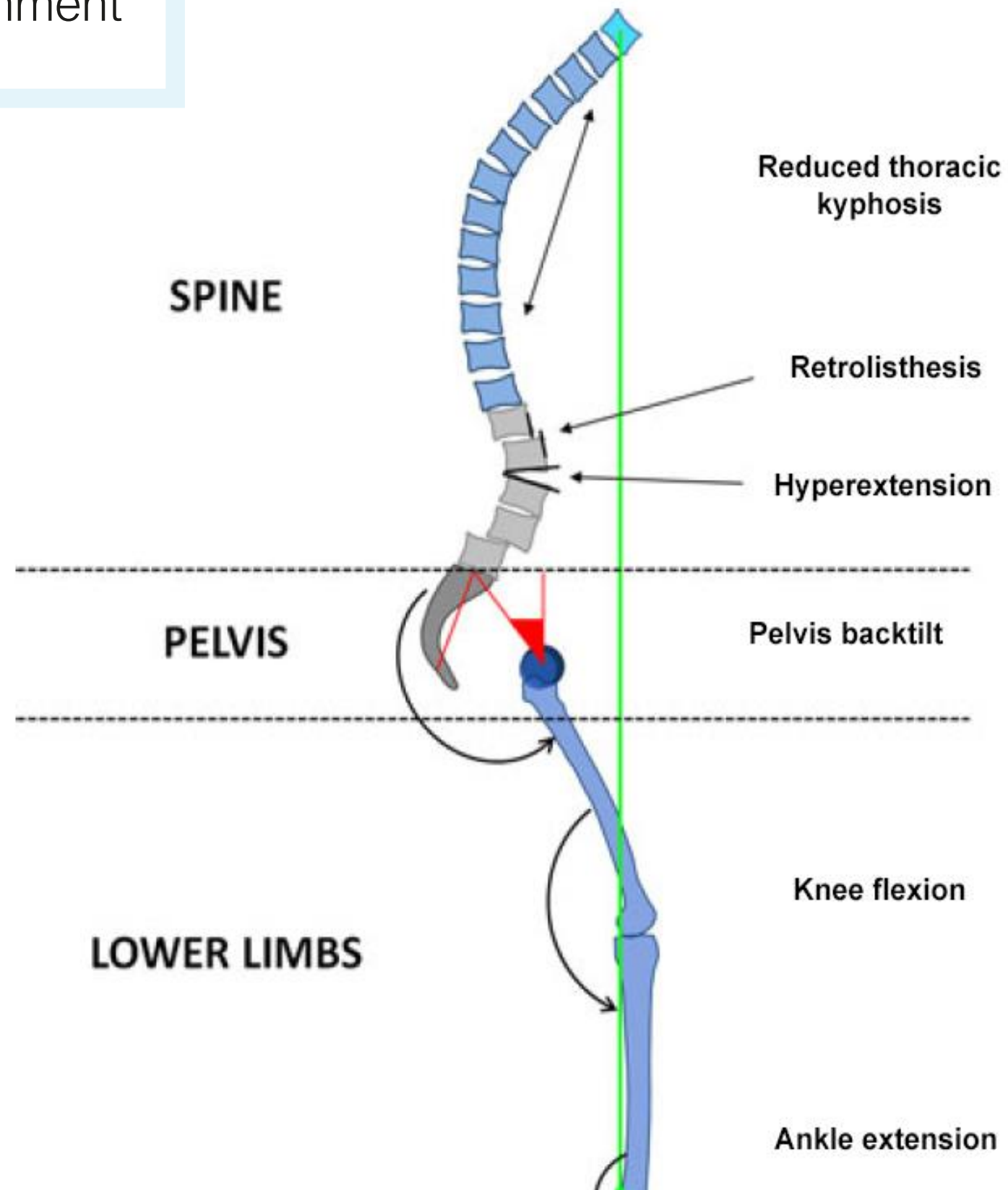
9

ORTHOFIX
 \$434M Total Sales
 \$82M Spine Sales
 \$1B Mkt Cap
 Spinal Kinetics

10 US companies control 85% of the worldwide market

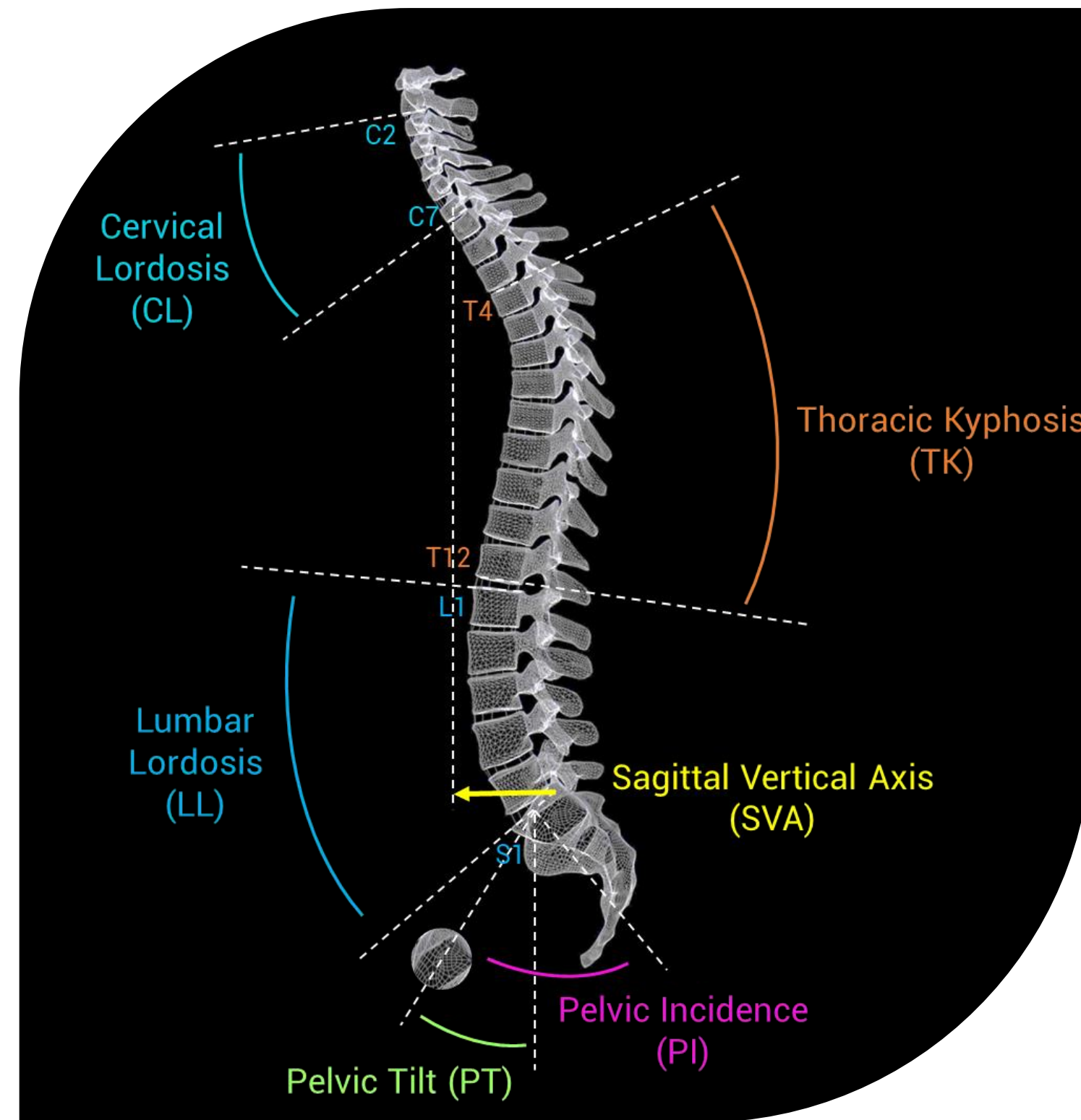
ALIGNMENT CONSIDERATIONS ARE COMPLEX

Compensatory mechanisms for sagittal malalignment

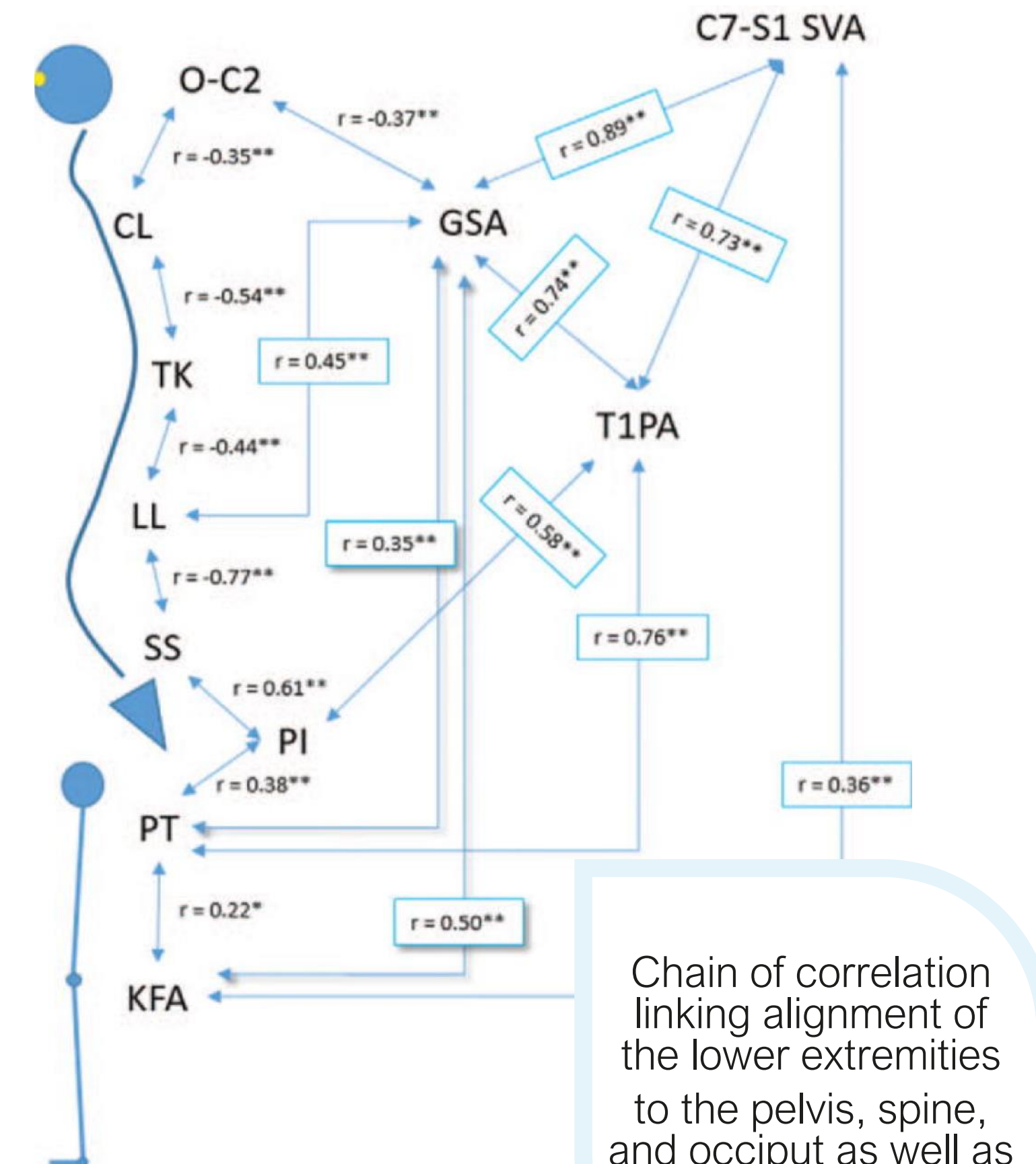


Source: Barrey et al., 2011

Alignment parameters are unique to each patient and vary based on the patient's age and compensatory factors.¹



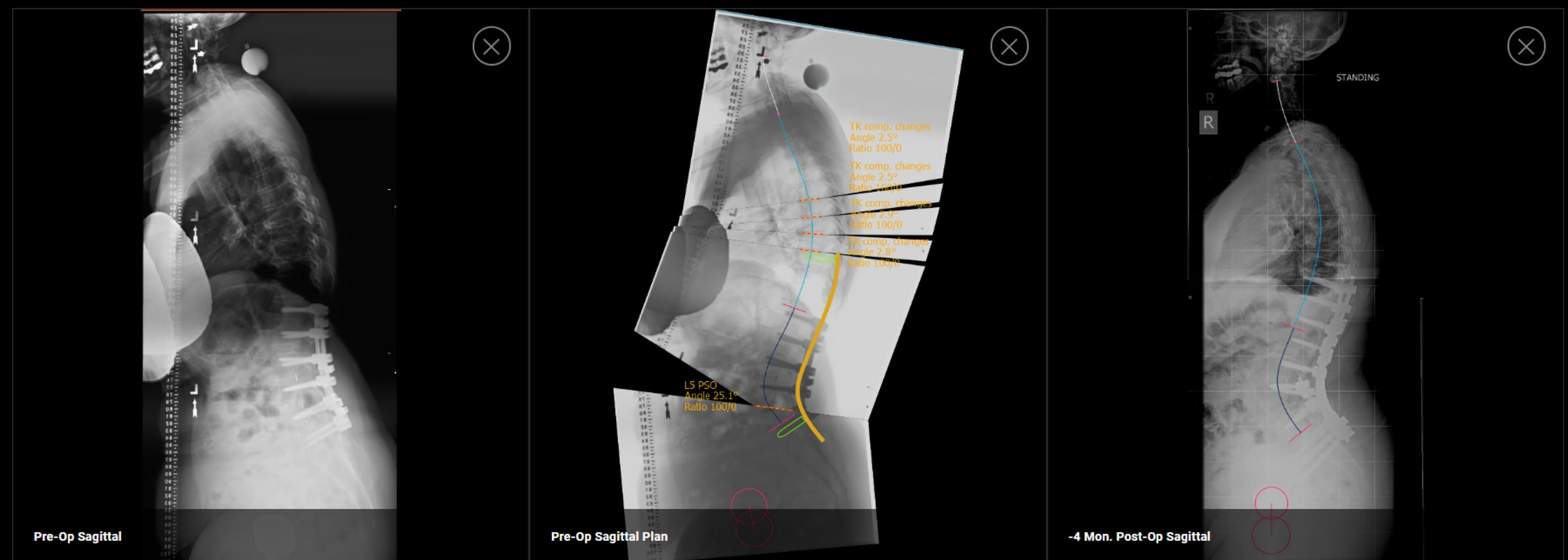
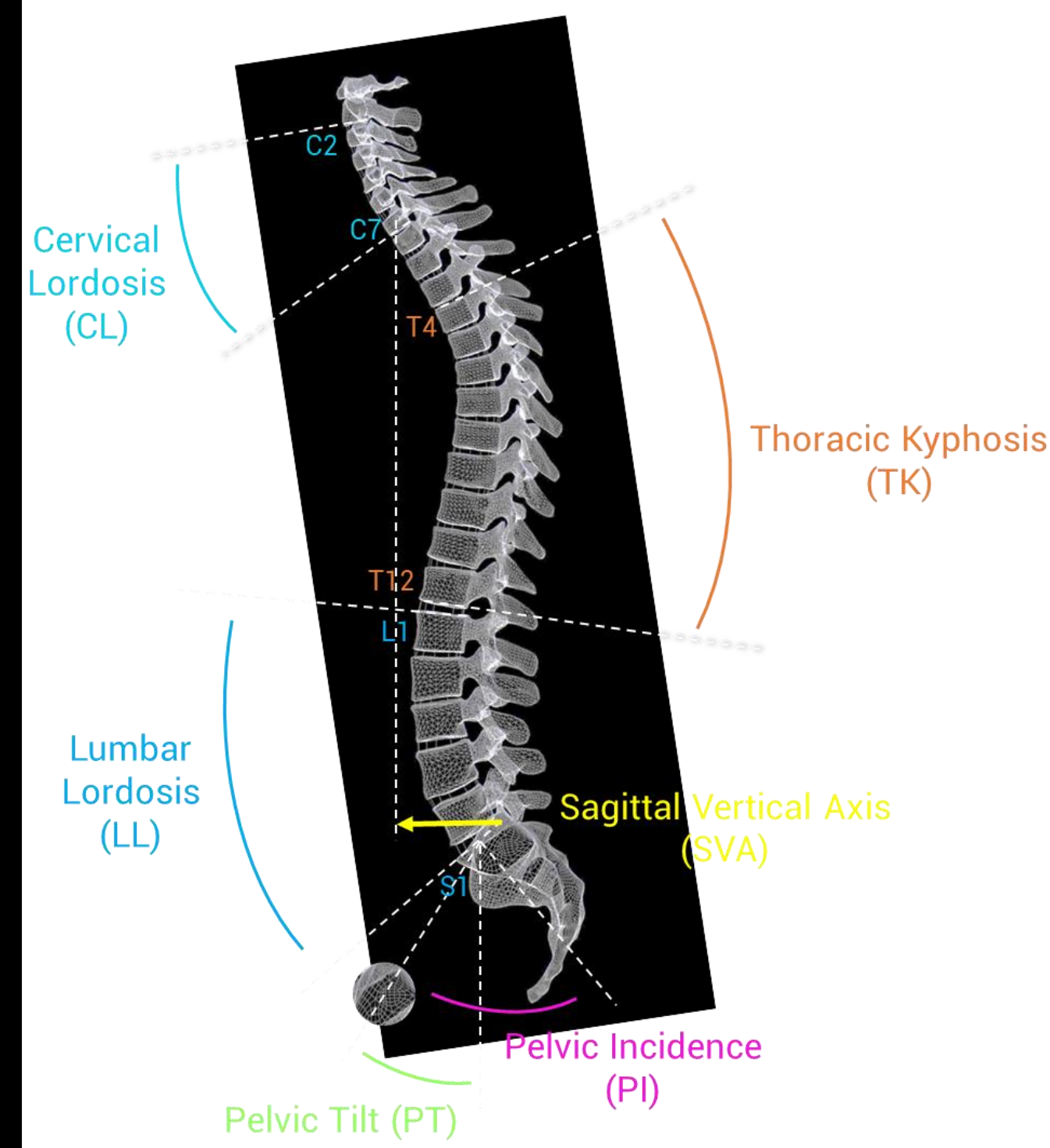
Source: Iyer, Lenke, et al., 2016



1. Iyer S, Lenke LG, Nemani VM, Albert TJ, Sides BA, Metz LN, Cunningham ME, Kim HJ (2016) Variations in sagittal alignment parameters based on age: a prospective study of asymptomatic volunteers using full-body radiographs. Spine

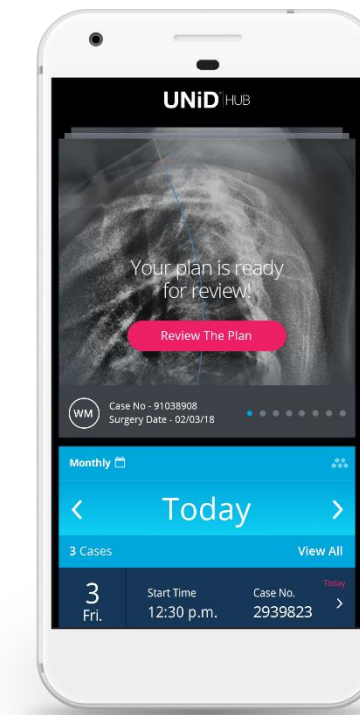
Spinopelvic Parameters

	Pre-Op	Plan	-4 Mon. Post-Op
Pelvic Tilt, PT (°)	22	18	18
Pelvic Incidence, PI (°)	52	52	58
Sacral Slope, SS (°)	29	34	39
Lumbar Lordosis, LL (°)	-29	-54	-58



UNiD™ | ASI

Adaptive Spine Intelligence
is driven by science to
improve patient outcomes
and economics



Strategic
PLANNING ACCURACY



Precision through
PERSONALIZATION



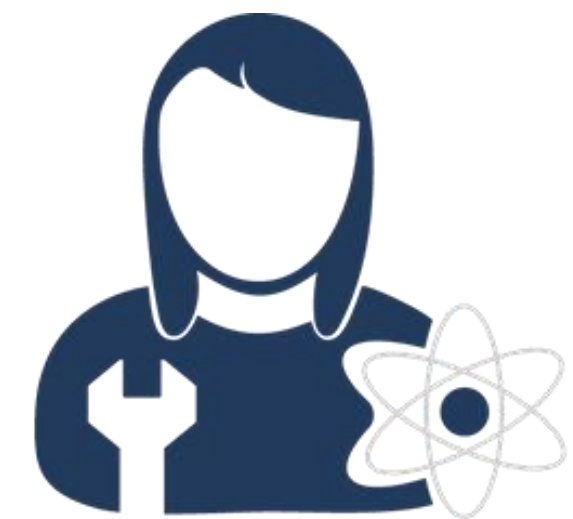
Iterative
PREDICTIVE ANALYTICS

UNiD ASI: A REVOLUTIONARY APPROACH AND PROCESS

- Opportunity to dramatically improve patient outcomes
- System combines: Software, Services and Patient-Specific Implant Solutions
- Becomes a vital part of a surgeon's patient workflow: Pre-Op, Intra-Op, Post-Op



SOFTWARE-CENTRIC PLATFORM: PROPRIETARY & 510(K) CLEARED



UNiD LAB

- Imaging Analysis
- Surgeon Preference Profile
- Predictive Modeling
- Case Simulations
- Engineering Design



Surgeon

- Reviews LAB Simulations
- Approval & Responsibility
- Feedback builds Profile

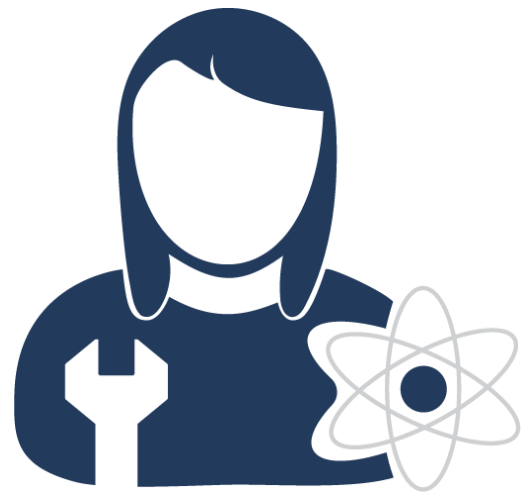


UNiD Software

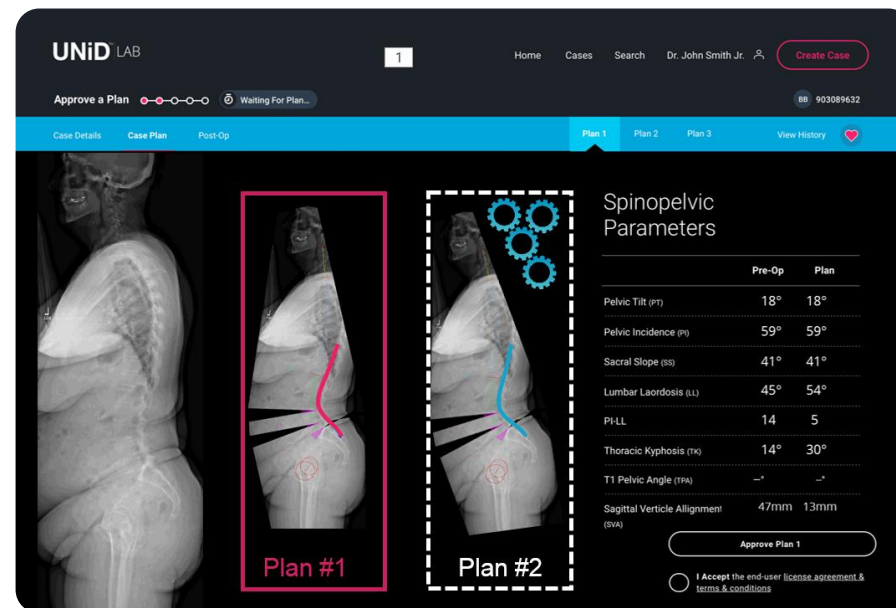
- Communication & Workflow
- Documentation and Approval Management
- Image & Data Management
- Cloud-based & HIPAA-compliant



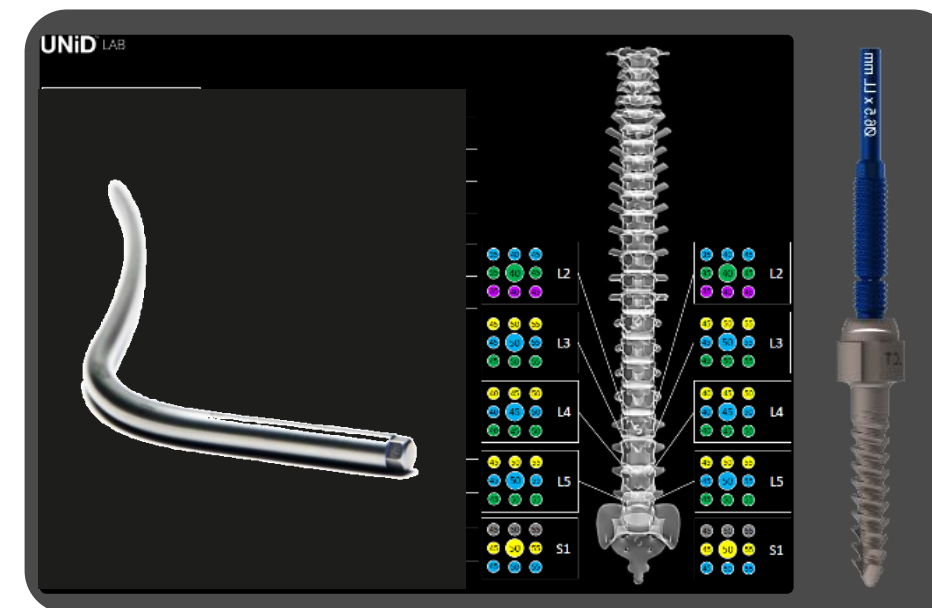
SERVICES EXTENDED THROUGHOUT PATIENT CARE PROCESS



PRE-OP SERVICES



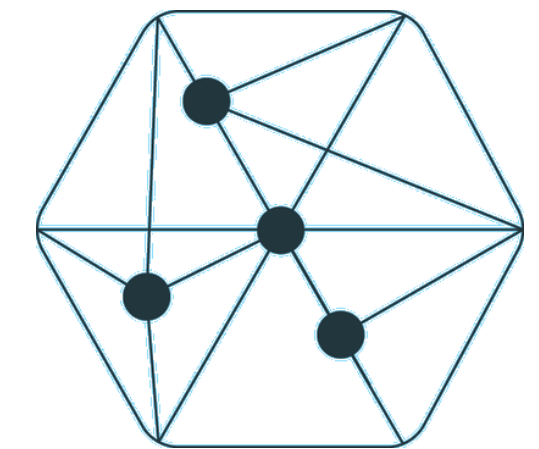
INTRA-OP SERVICES



POST-OP SERVICES



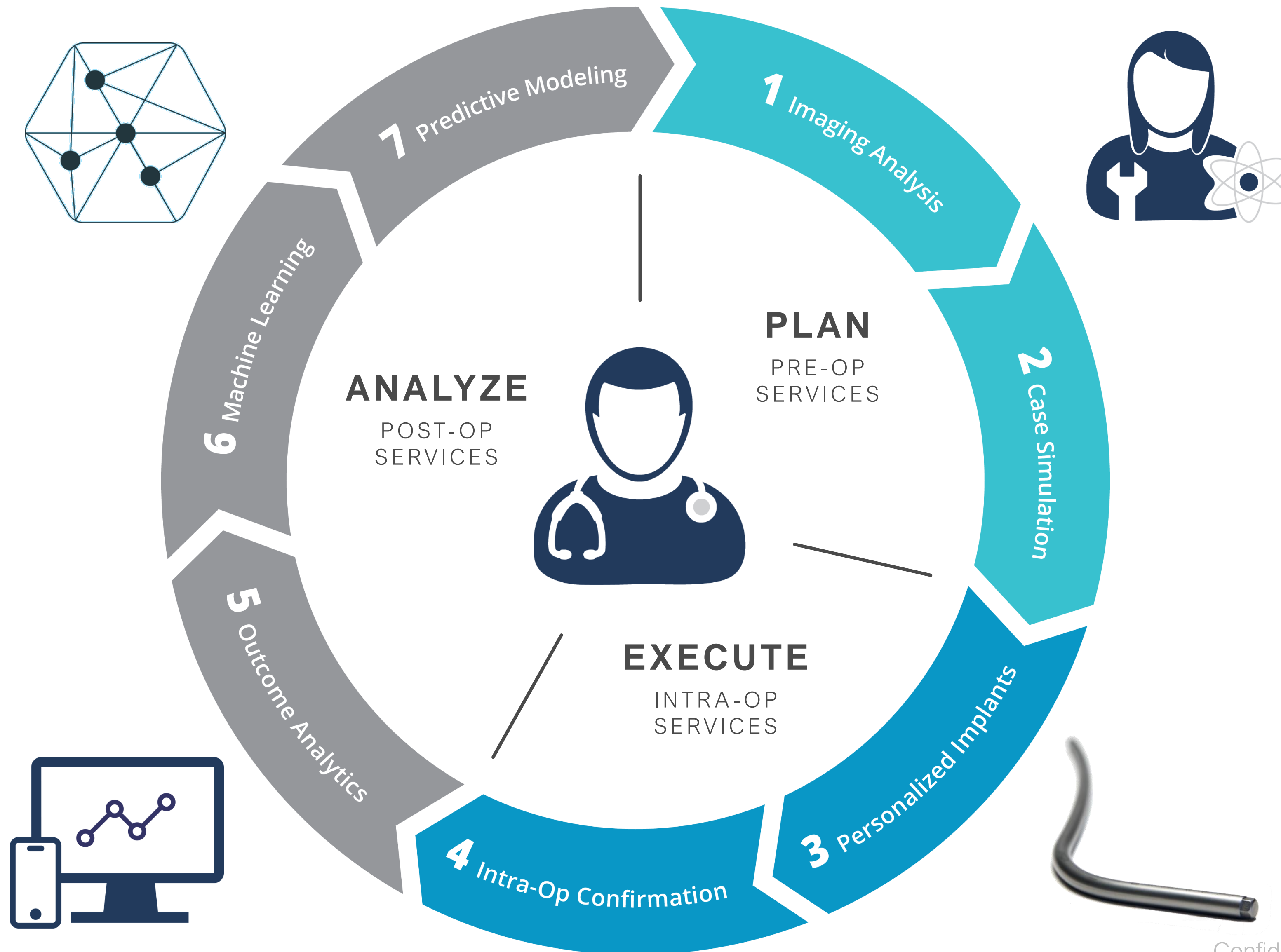
ASI PROCESSING



STRENGTHENS WITH EVERY PATIENT:

- Surgeon: Confidence in system
- LAB: Surgeon's preference profile
- ASI: Data for Machine Learning

VIRTUOUS IMPROVEMENT PROCESS

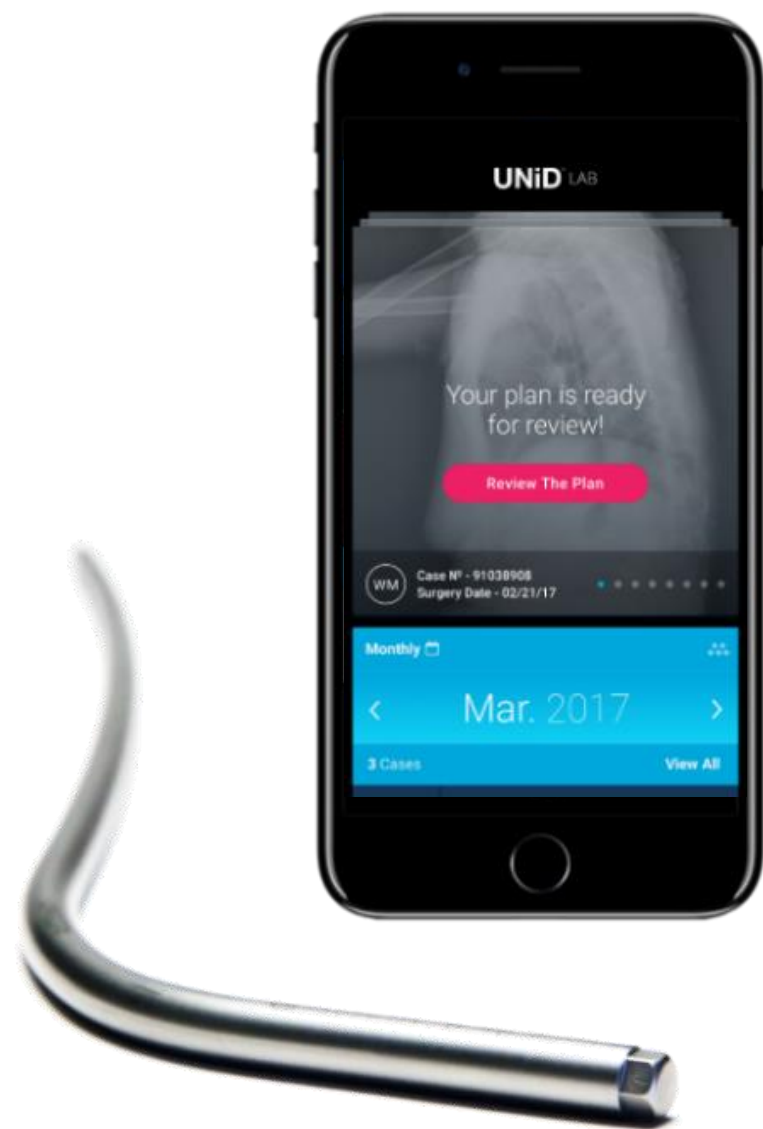


UNiD HUB SOFTWARE

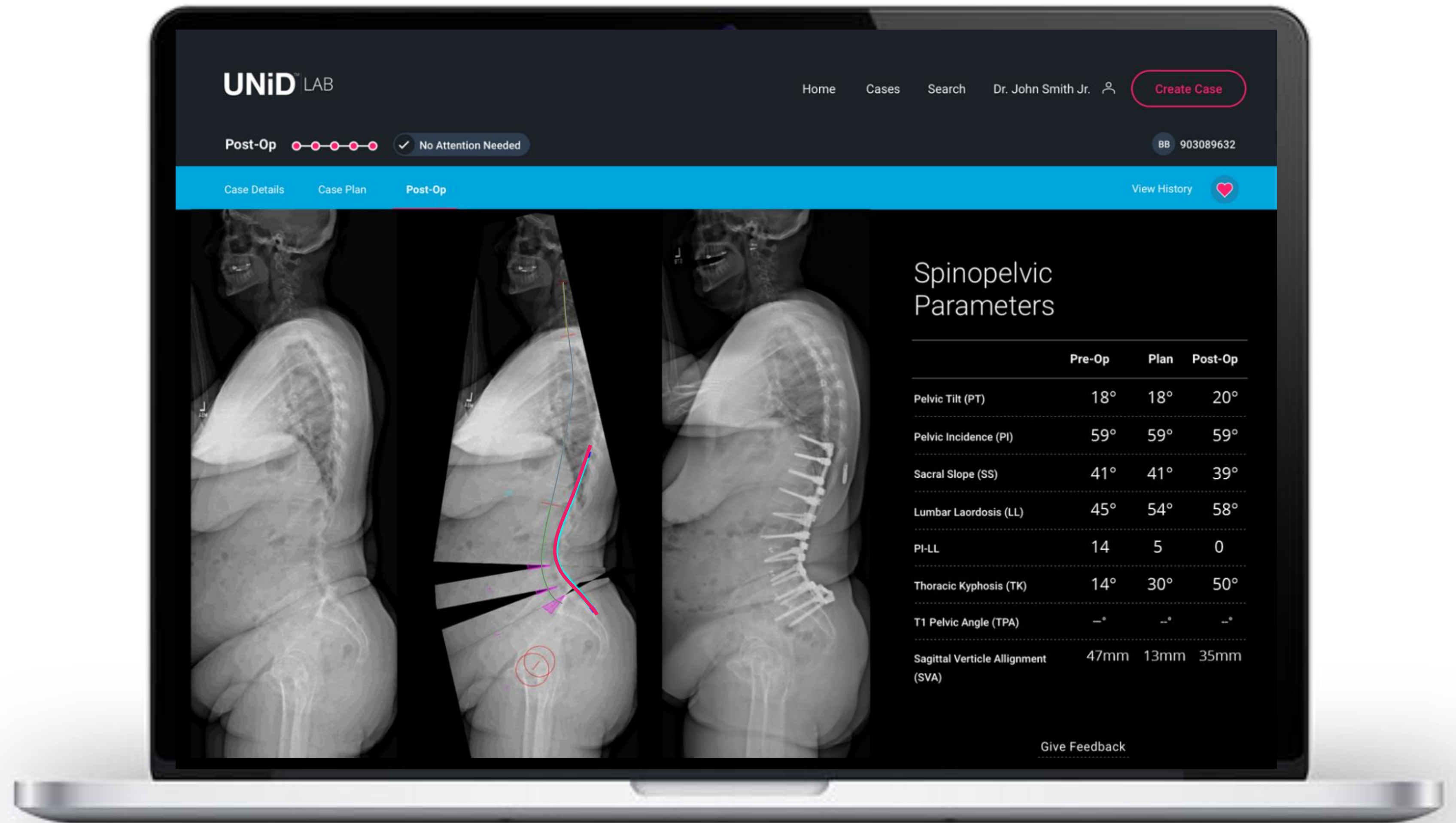
Planning Service

- Imaging Analysis
- Surgeon Preference Profile
- Case Simulations
- Predictive Modeling

Case Planning approval



Case Postoperative Analysis



OUTCOME ORGANIZATION, ANALYTICS & VISUALIZATION

Database of surgeon cases

Cases filtering by PI value, patient age & gender, instrumented levels, ...

Live comparison of pre-op, planned & postop parameters for selected cases

Case by case parameters evolution



Publication / Research Engine

POWERED BY PROPRIETARY MACHINE LEARNING AND PROPRIETARY PREDICTIVE MODELING

Predictive Model #1: prediction of **compensatory mechanisms** outside the instrumentation

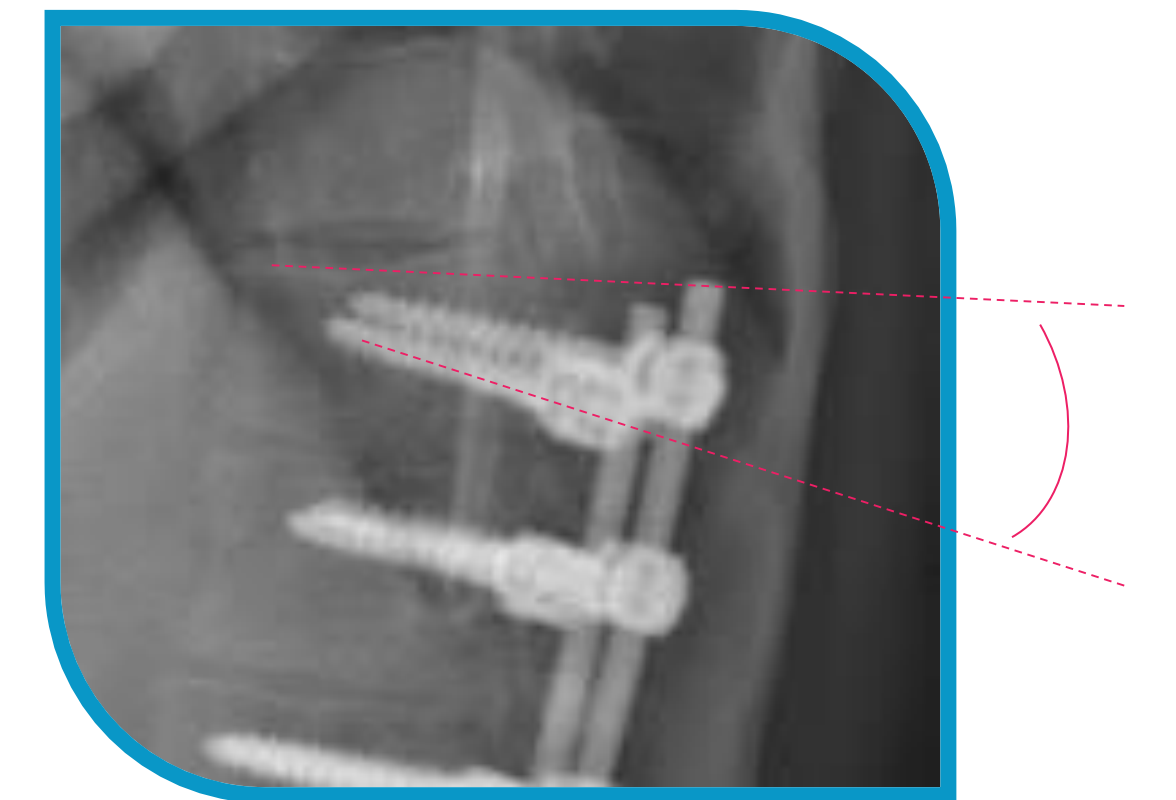
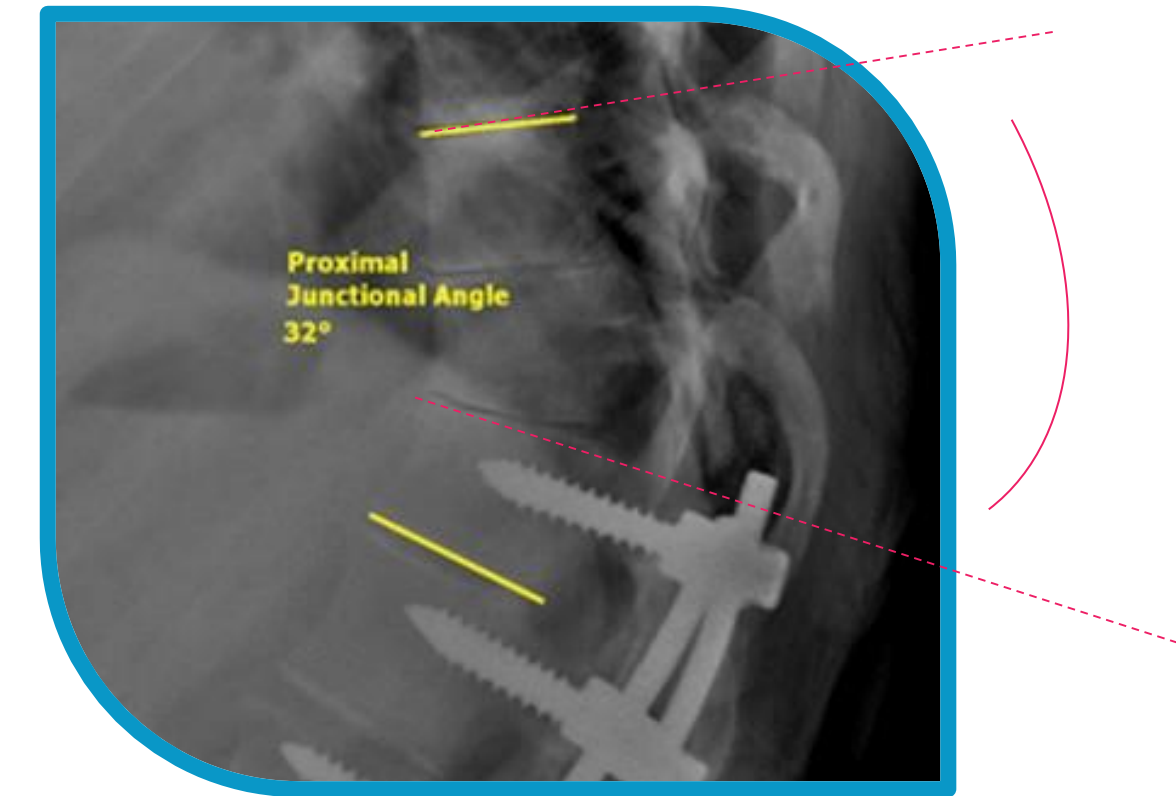
→ Improve reliability of our planning simulations in terms of SVA, PT, TK...

Predictive Model #2: prediction of **implant shape (rod)** linked to rod/spine position, vertebral dimensions & surgeons technique

→ Improve design of implants to insure effectiveness of UNiD Implant

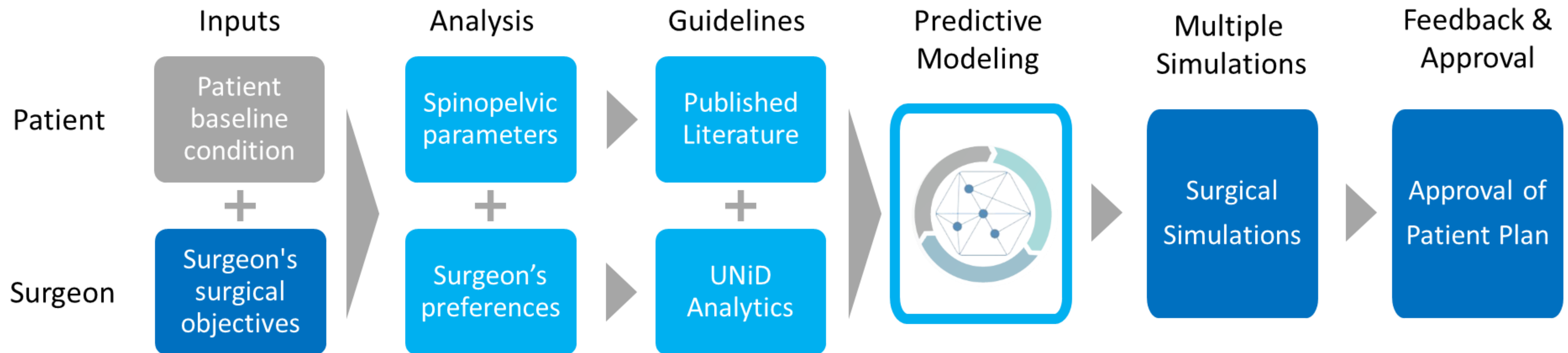
Predictive Model #3: Simulation of **different strategies/instrumentation** using models #1 & #2 to achieve the optimal correction at 2 years after surgery

→ Decision making support (levels instrumented, personalized alignment...)

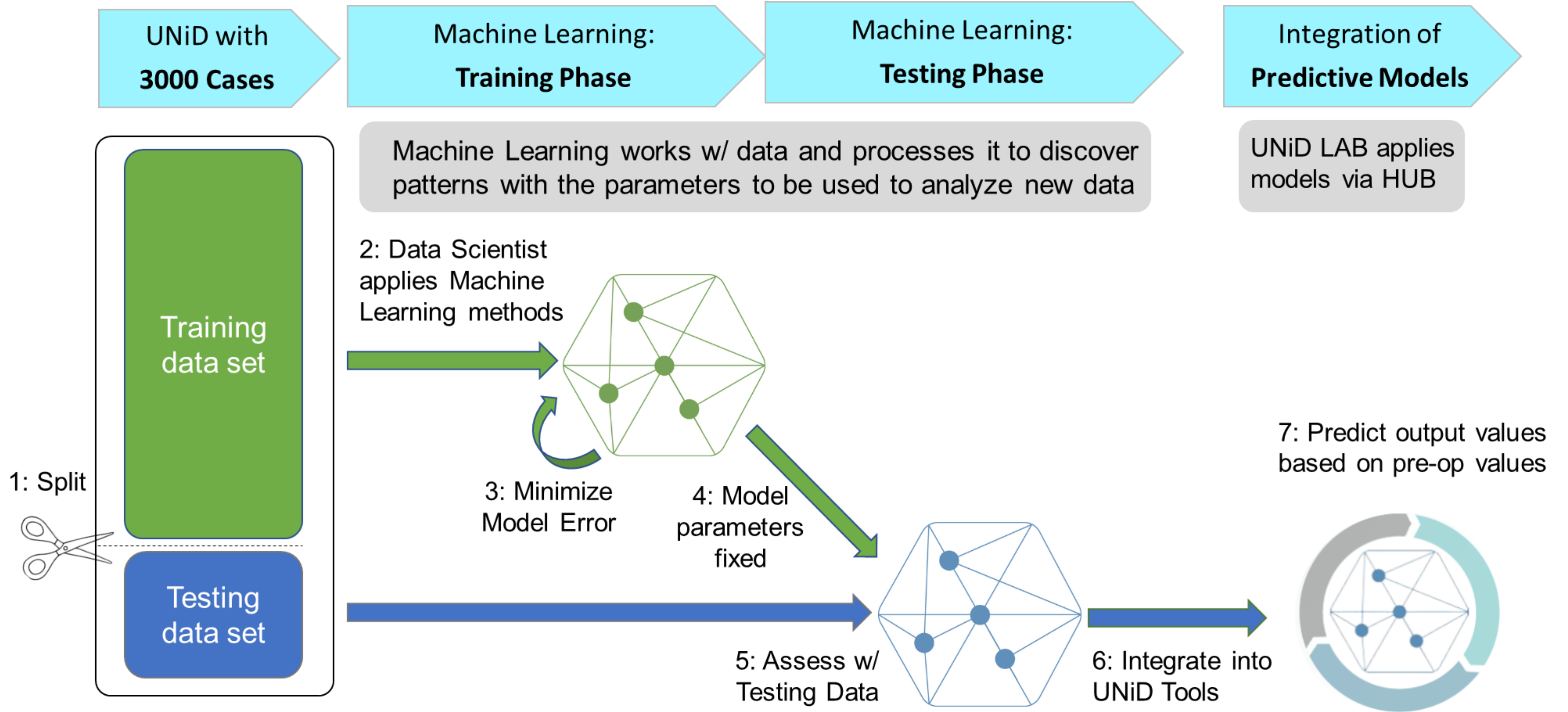


THE ROLE OF AI IN UNiD SURGICAL PLANNING

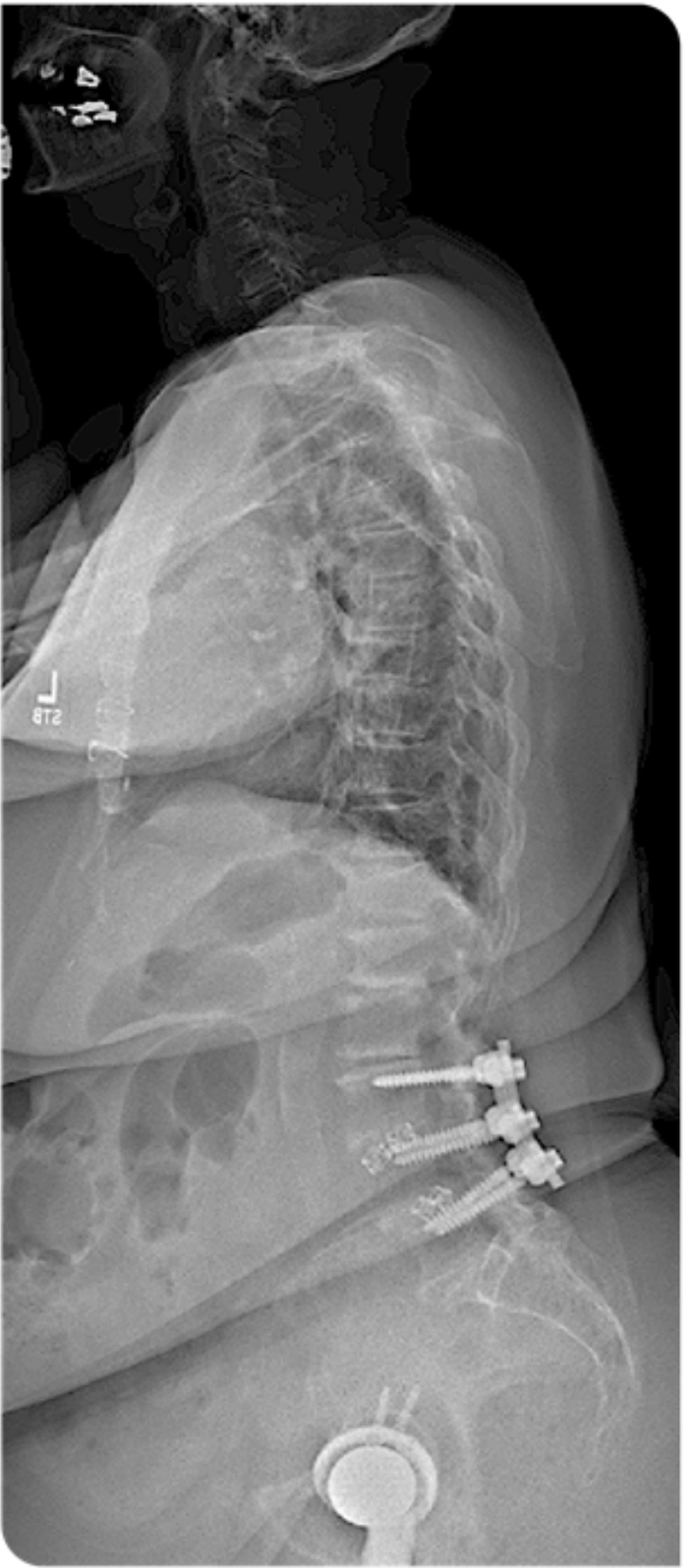
- UNiD Lab Engineers use proprietary tools to develop surgical simulations
- UNiD HUB facilitates collection of critical inputs on Patient's condition and the Surgeon's objectives
- LAB Engineer utilizes UNiD toolkit to develop simulations including Predictive Modeling



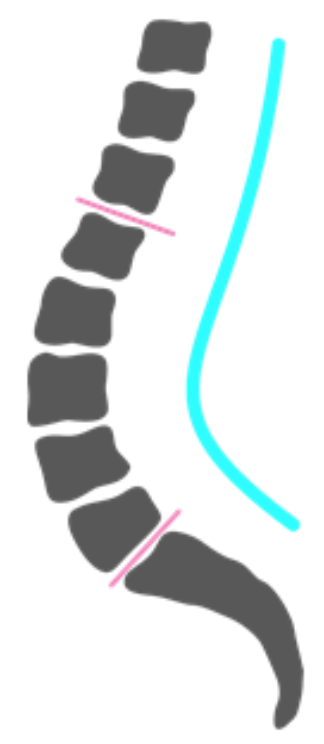
MACHINE LEARNING OVERVIEW



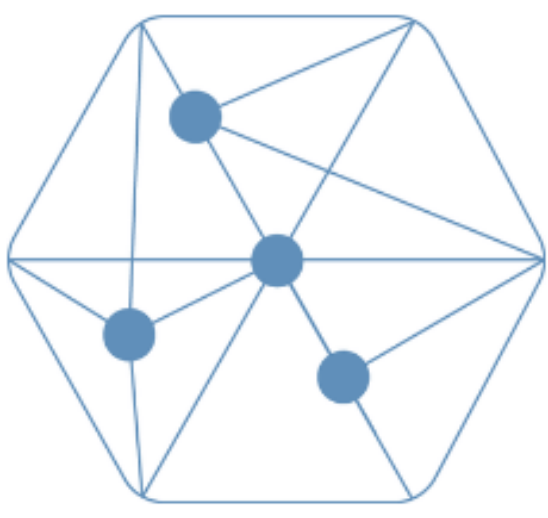
PREDICTIVE MODELING IN ACTION WITH UNiD



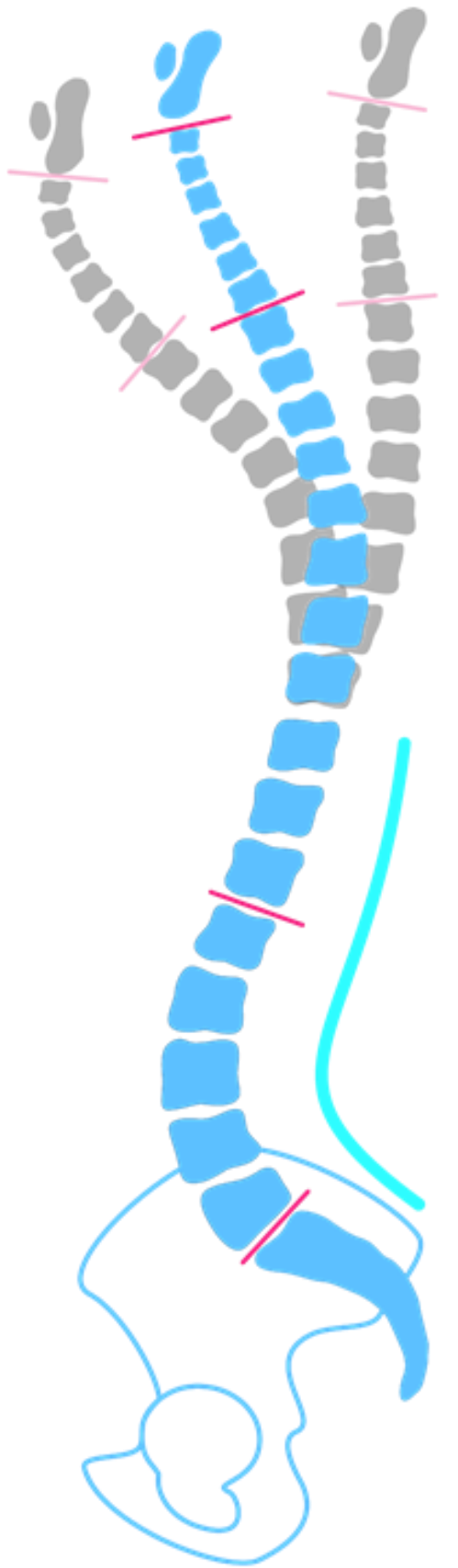
Pre-Op Parameters



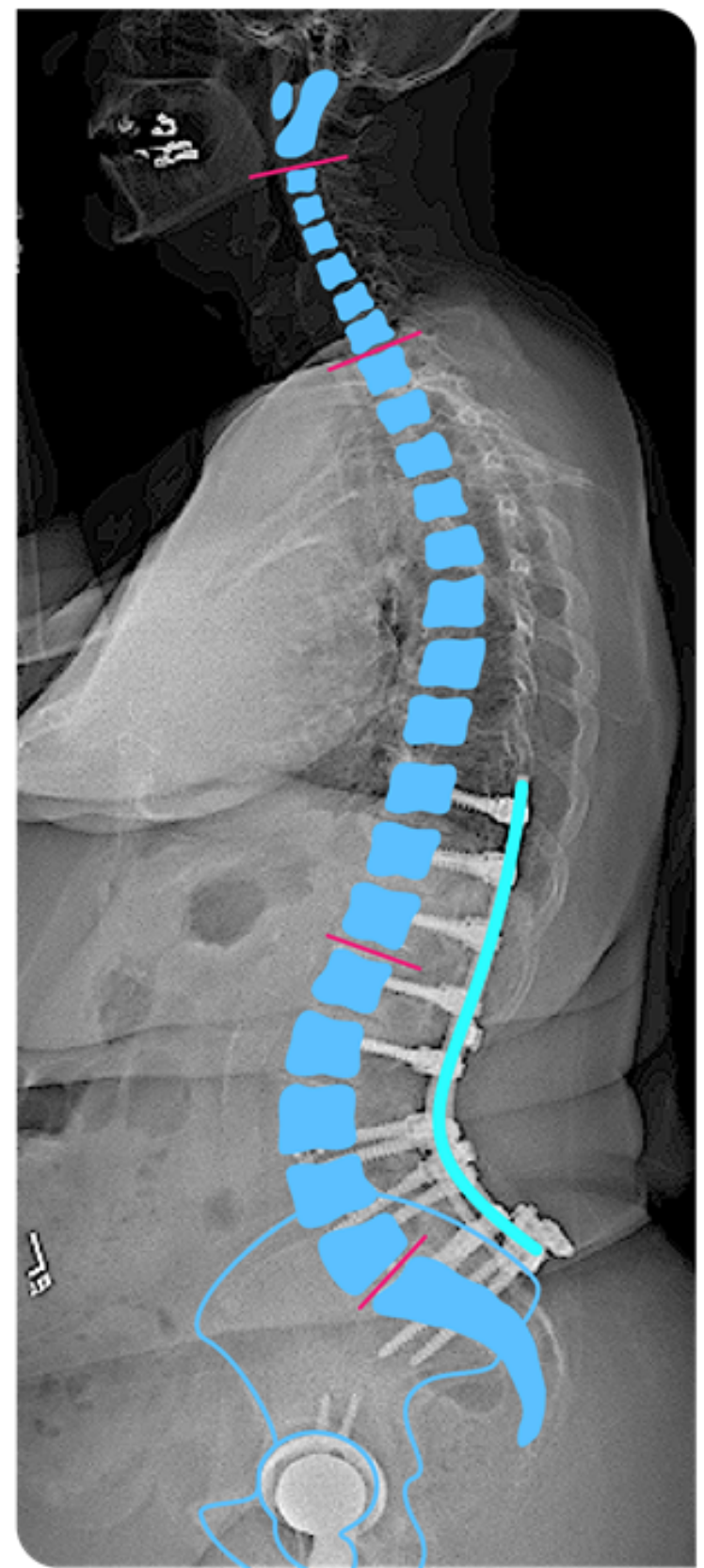
Apply Surgical Plan



AI Engine



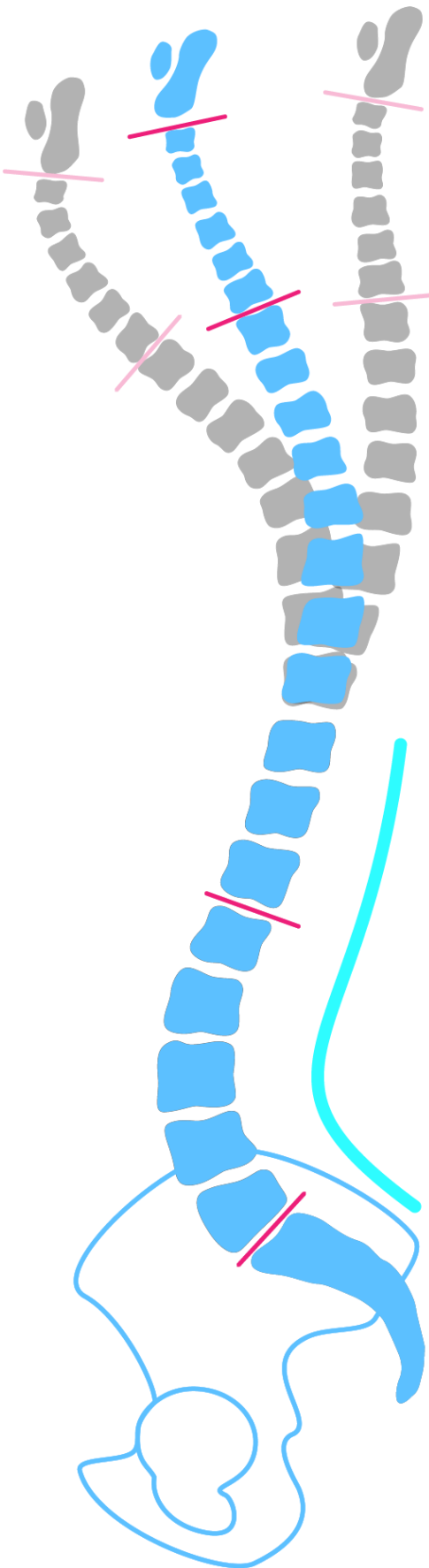
Predictive Model



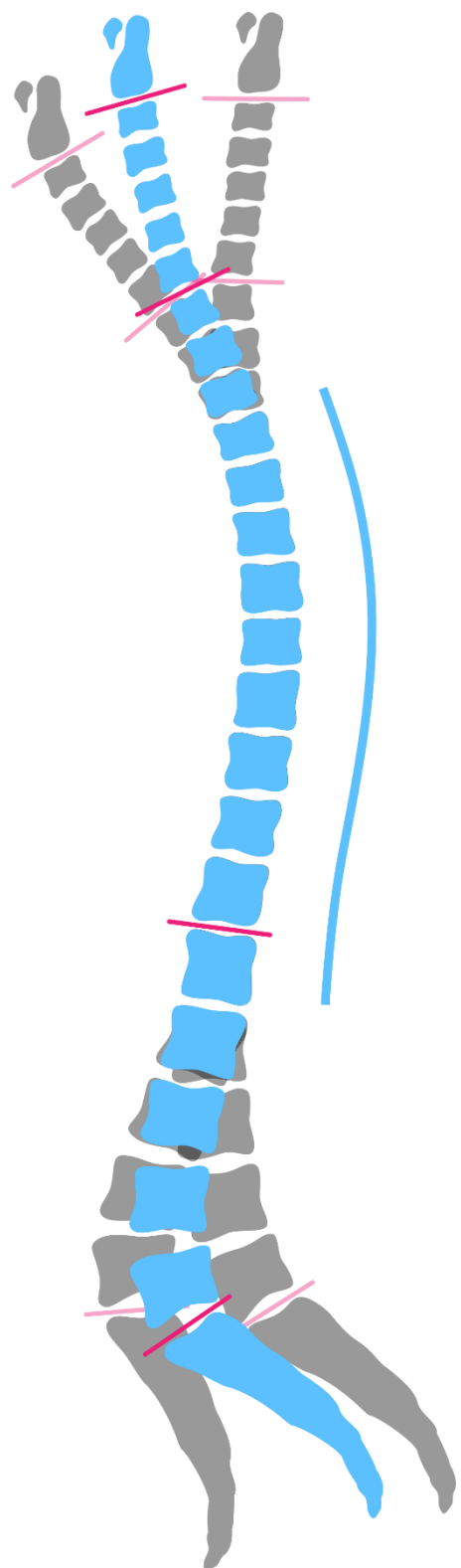
Compare to Post-op Result

2 PREDICTIVE MODELS IN USE BY UNiD LAB

#1 ASD (adults) compensatory mechanisms predictive model
Available Since: 7/2017



#2 AIS (adolescents) compensatory mechanisms predictive model
Available Since: 1/2018




INITIAL CLINICAL OUTCOMES

> 3,000 UNiD cases with game-changing clinical findings.



85%

Reduction in ASD Rod Fracture rate^{1,2}



75%

Reduction in Rod Flattening Deflection³

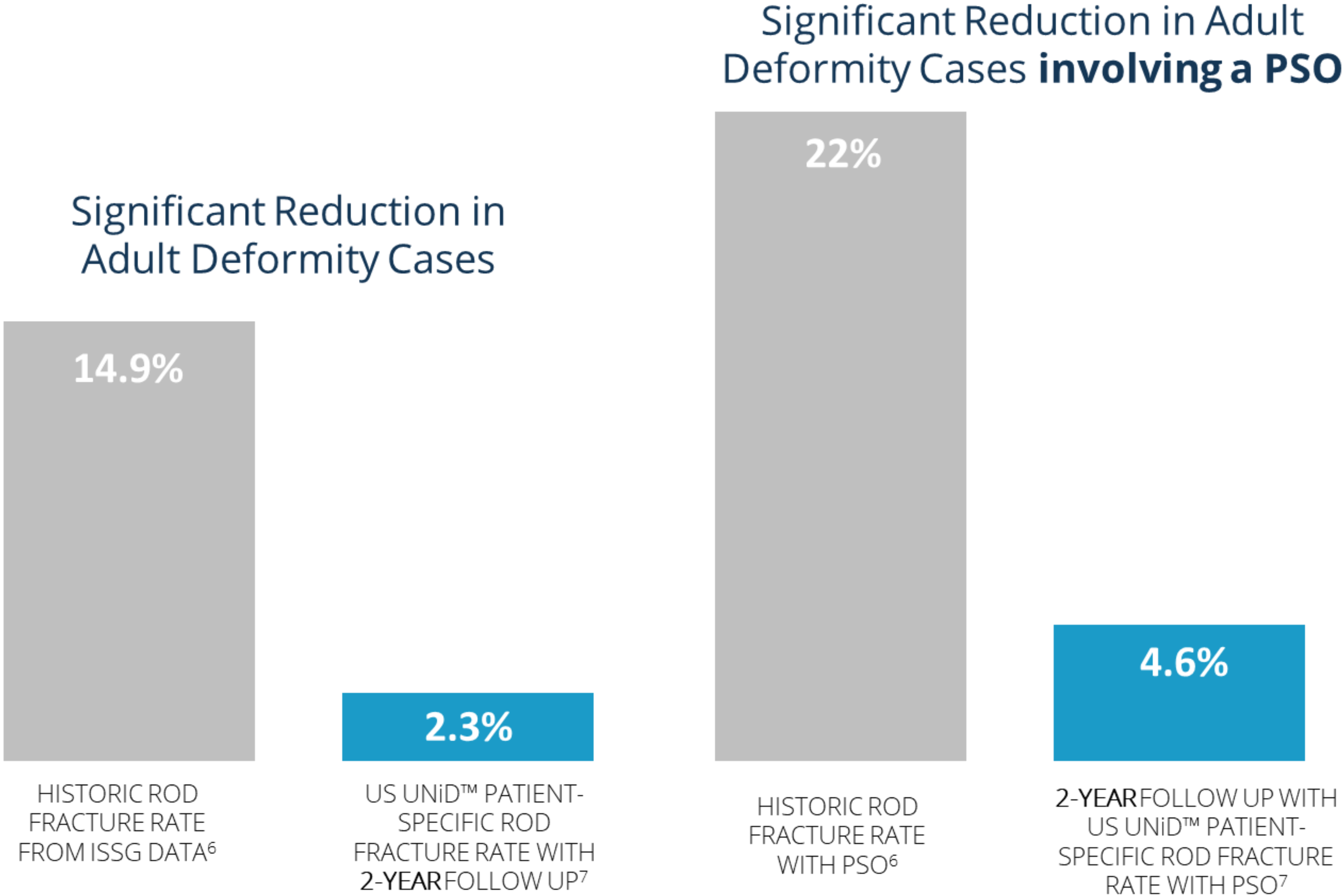
Utilizing patient-specific rods designed and manufactured by Medicea's UNiD ASI technology solves known issues around rod fracture, rod flattening and malalignment.

1. Hamilton DK, Buza JA, Passias PG, et al. The Fate of Adult Spinal Deformity (ASD) Patients Incurring Rod Fracture After Thoracolumbar Fusion. World Neurosurgery. 2017.

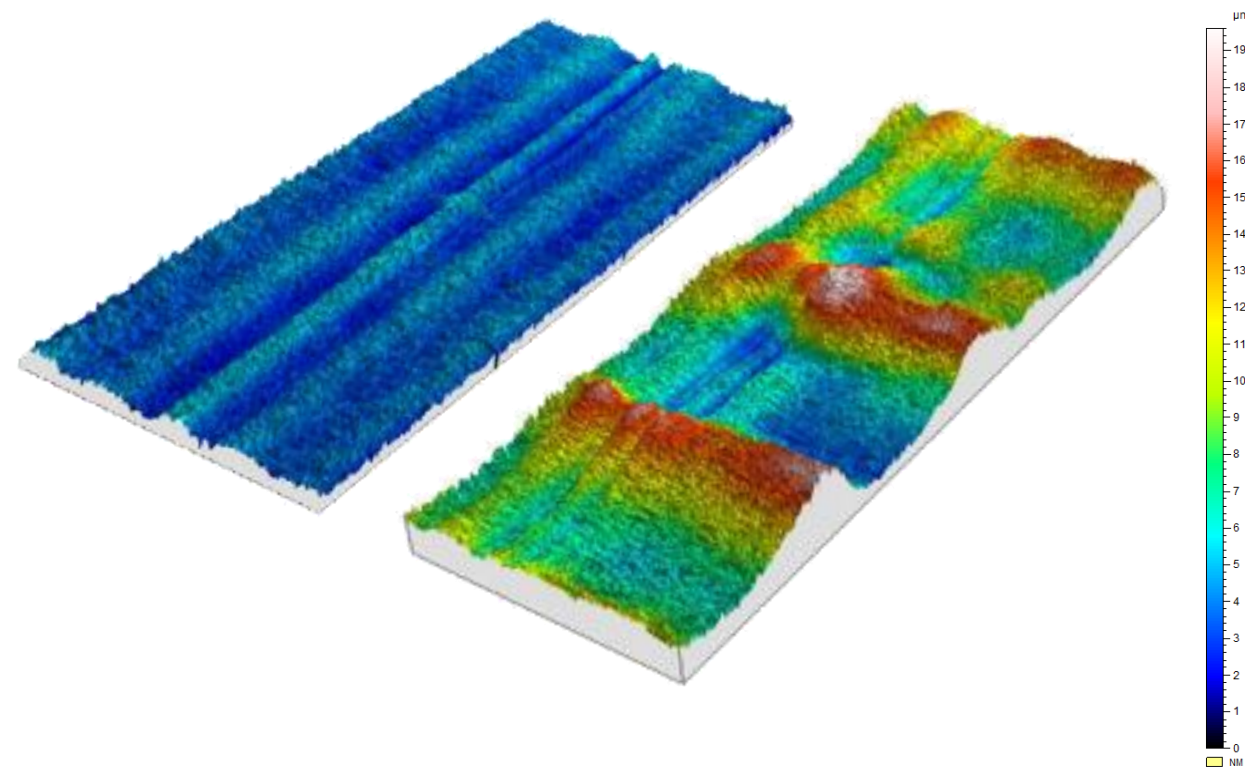
2. V. Fiere, S. Fuentes, E. Burger, T. Raabe, P. Passias, et al. Patient-Specific Rods show a reduction in rod breakage incidence. Medicea Whitepaper. October 2017.

3. A. King, A. Aminian, P. Alijanipour, et al. Analysis of pre-contoured Patient-Specific Rods in Adolescent Idiopathic Scoliosis using MATLAB - Does Rod Flattening Occur After Implantation? Abstract submitted for IMAST 2018.

ROD FRACTURE RATE REDUCTION: 2-YEAR FOLLOW-UP



PATIENT SPECIFIC ROD : FULL LAUNCH : 3,000 CASES



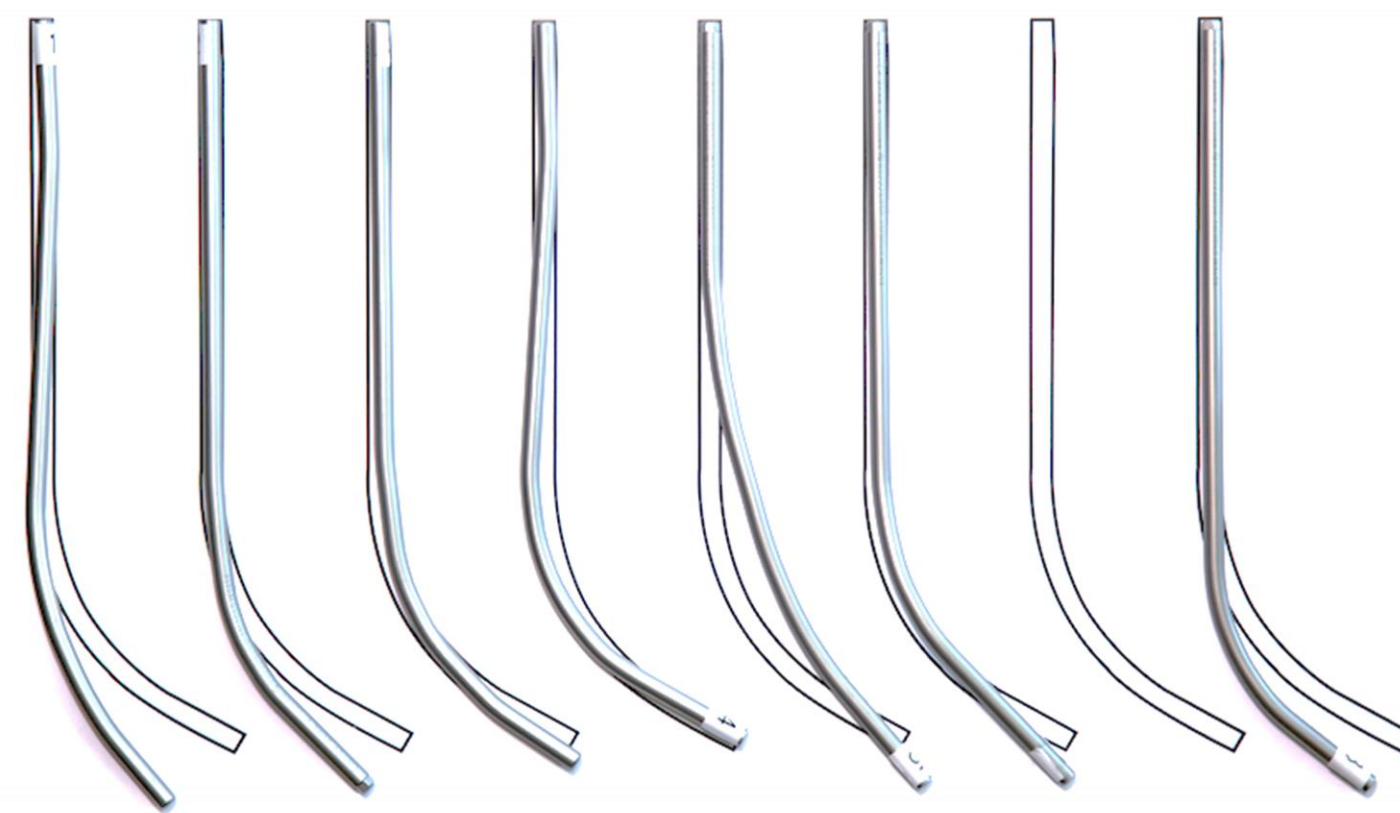
Strength

Surface Analysis

with 3D Optical Profilometer

Left: Smoothly-contoured UNiD Patient-Specific Rod

Right: Traditional manually-bent rod (Non-contract measurement & analysis)



Accuracy

The Art of Rod Bending¹

Qualitative comparison between the real shape and the bending obtained by surgeons exhibited a high degree of variability

Intra-Operative Confirmation

The UNiD Rod is a physical representation of the Surgical Plan aiding in goal achievement



Time Savings

\$1,500 per case

Savings by procedure by minimizing manual rod bending in the O.R. (15 min @ \$100/min²) and pulls attention from away from the patient.

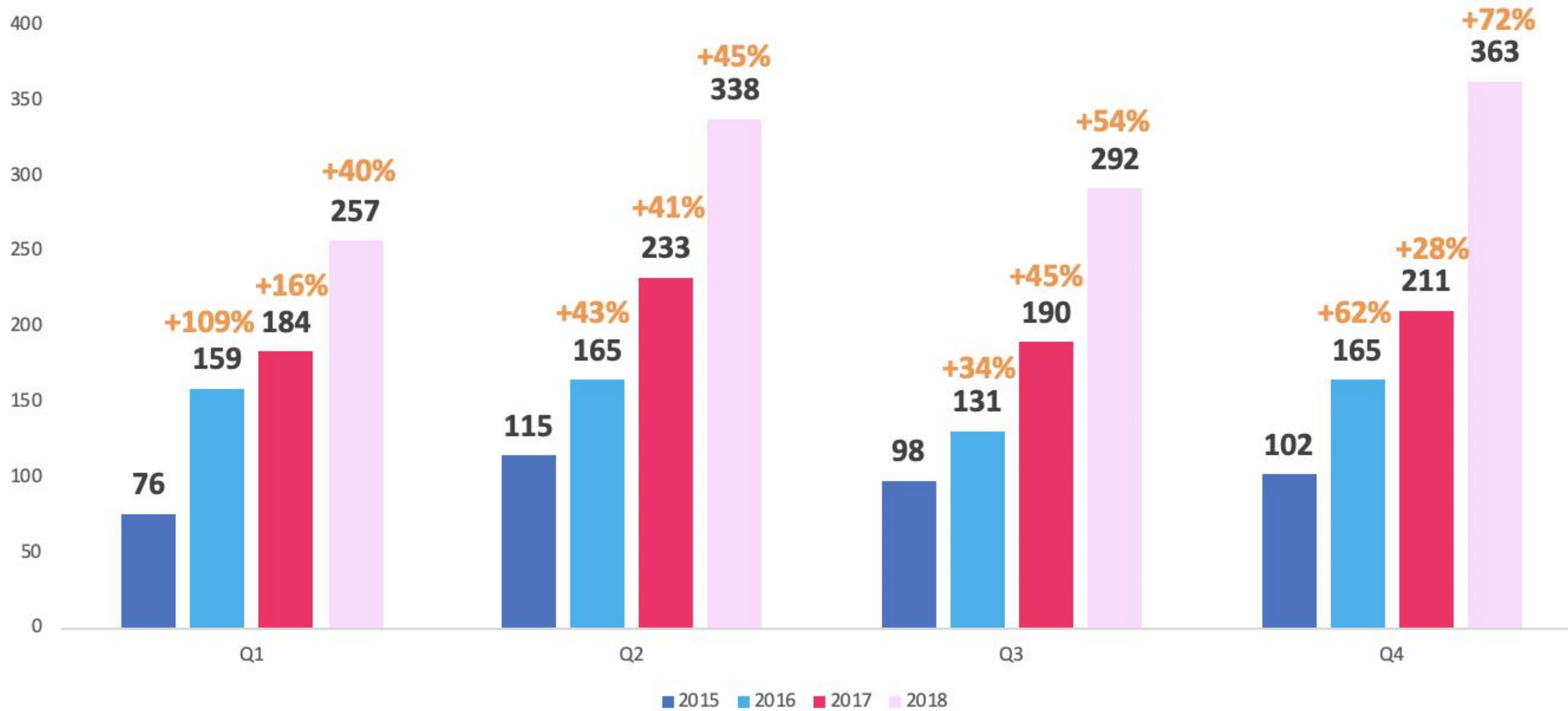
1. Rod bending lab organized in 2012 included 8 spine surgeons and fellows from major US teaching institution

2. Fletcher D, Edwards D, Tolchard S, et al, Improving theatre turnaround time, BMJ Open Quality 2017;6:u219831.w8131. doi: 10.1136/bmjquality.u219831.w8131

UNiD PUBLICATIONS AND PRESENTATIONS

Year	Kind	1st Author	Title	Journal or Congress
2018	Publication	Solla F	Patient specific rods for surgical correction of sagittal imbalance in adults: technical aspects and preliminary results	Clin Spine Surg
2018	Publication	Passias	Pre-operative planning and rod customization may optimize post-operative alignment and mitigate development of malalignment in multi-segment posterior cervical decompression and fusion patients	Journal of Clinical Neurosciences
2018	Podium	Fière V	Patient-Specific Rods show a reduction in rod breakage incidence	ISASS 2018 Toronto (TBD) SSA 2018 Adelaide (TBD)
2018	Poster	A. King	Radiographic Comparison of Patient-Specific and Manually Contoured Conventional Rods in Adolescent Idiopathic Scoliosis (AIS) Surgery	IRSSD
2018	Podium	P. Passias	Patient-Specific Rods show a reduction in rod breakage incidence	ISASS
2018	Poster	Blondel B	Surgical Planning and Patient-Specific Rods Improve Correction of Sagittal Malalignment in Adult Spinal Deformity	ISASS
2018	Poster	P. Passias	Pre-Operative Planning and Rod Customization May Optimize Post-Operative Alignment and Mitigate Development of Malalignment in Multi-Segment Posterior Cervical Decompression and Fusion Patients	AANS
2018	Poster	PJ. Holman	Utility of Patient Specific Rod Instrumentation in Deformity Correction: Single Institution Experience	AANS
2018	Podium	Aminian A	Analysis of Pre-Contoured Patient Specific Rods in Adolescent Idiopathic Scoliosis using Computer Software- Does Rod Flattening Occur After Implantation?	IMAST
2017	Podium	V. Fiere	Are Patient-Specific Rods Effective to Manage Adult Spinal Deformity	Eurospine
2017	Poster	V. Fiere	Surgical Planning and Patient-Specific Rods Improve Correction of Sagittal Malalignment in Adult Spinal Deformity	NASS
2016	Publication	Barton	Early Experience and Initial Outcomes With Patient-Specific Spine Rods for Adult Spinal Deformity	Orthopedics
2015	Podium	Solla F	Patient specific rods for surgical treatment of spine imbalance in adult	ISSNC
2014	Podium	Fière V	Preoperative planning and patient specific rods for surgical treatment of thoracolumbar spine imbalance.	Eurospine

UNiDTM ASI PROCEDURES ADOPTION TREND



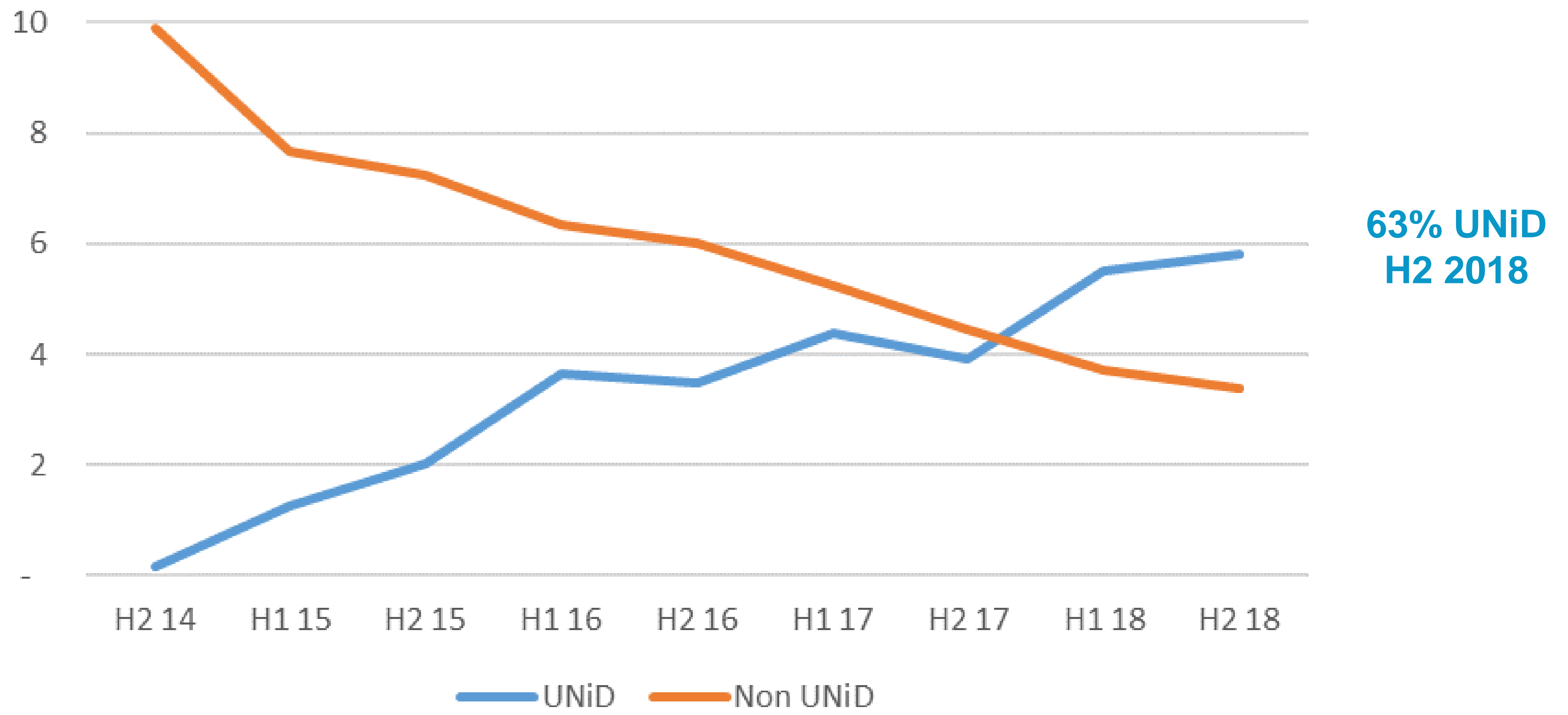
NUMBER OF PROCEDURES: 3,200 (12/31/2018 - Estimated)

9 80 391 620 818 1,260 (E)

2013 PROCEDURES 2014 PROCEDURES 2015 PROCEDURES 2016 PROCEDURES 2017 PROCEDURES 2018 PROCEDURES

TRADITIONAL VS UNiD REVENUE

(USA Revenue per Semester in \$'000)



GROWTH MODEL

MORE SURGEONS
using UNiD platform
and rods.

1

CONVERTED SURGEONS
increasing procedural share
of Medicea hardware.

2

STICKINESS
via UNiD HUB and
LAB services

3

ENGAGE

FULLY CONVERT

UNID RODs

UNID IBDs

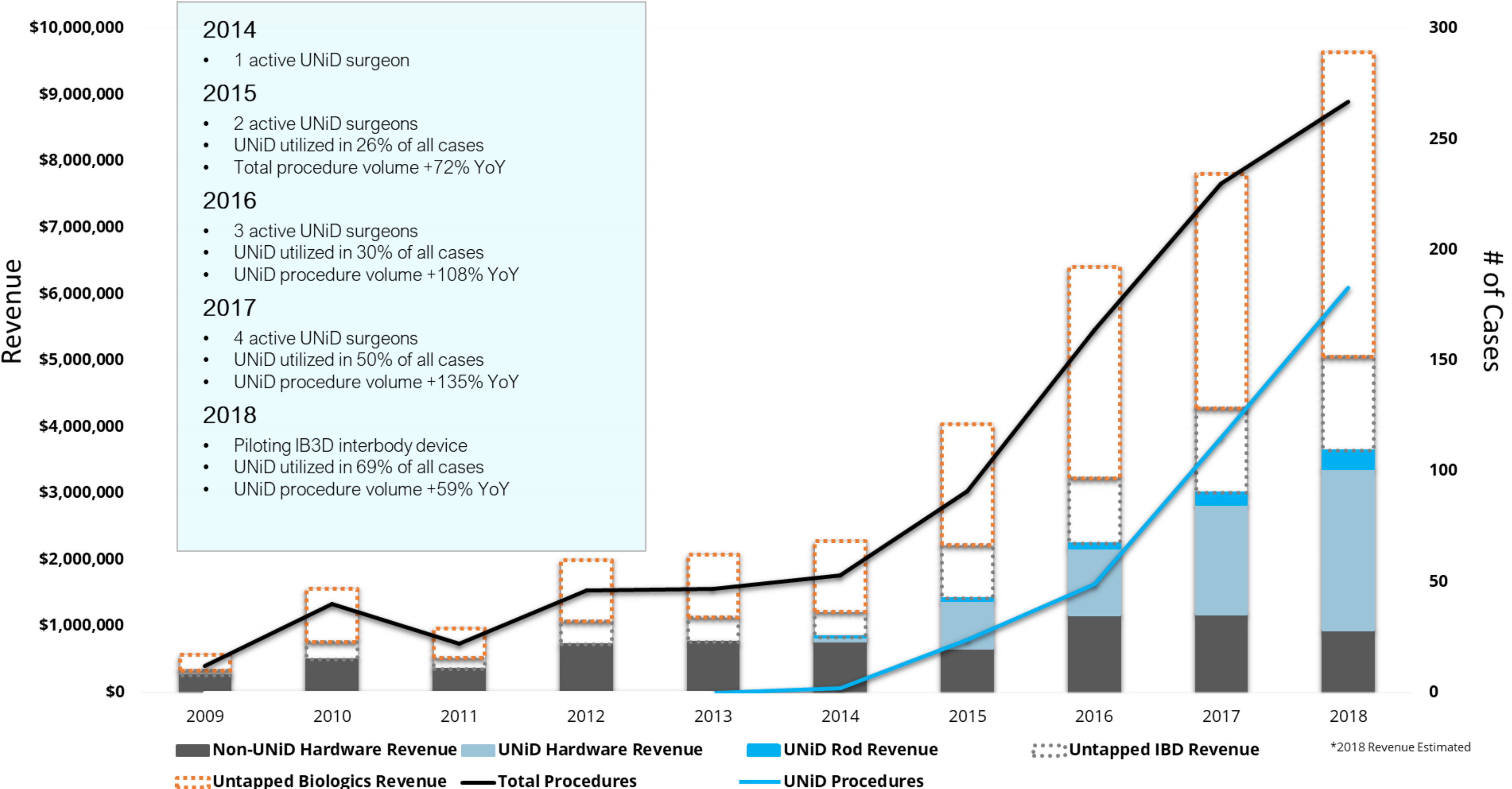
PEDICLE SCREWS

Least commoditized
Low conversion sensitivity



Most commoditized
Higher conversion sensitivity

UC DENVER CASE STUDY: UNiD IMPACT ON ADULT PROCEDURES



TOTAL PATIENT-SPECIFIC SOLUTION: ROD, SCREWS, CAGES

UNiD™ O.R. Case Memo Patient Initials: **DH** Surgeon Name: **K. Kebaish**

PRE-OPERATIVE PLAN

SURGICAL STEPS

SPO (12°)	T1-T2
PSO (25°)	T4
SPO (10°)	T10-T11

SCREW MARKS

Cranial	C3
Caudal	S1

ROD TYPE

(L)	3.5-5.5	Ti Alloy	Dual Ø
(R)	3.5-5.5	Ti Alloy	Dual Ø

EXTRA LEVEL(S)

Cranial
Caudal

LEVELS

C3-Pelvis

KEY PARAMETERS

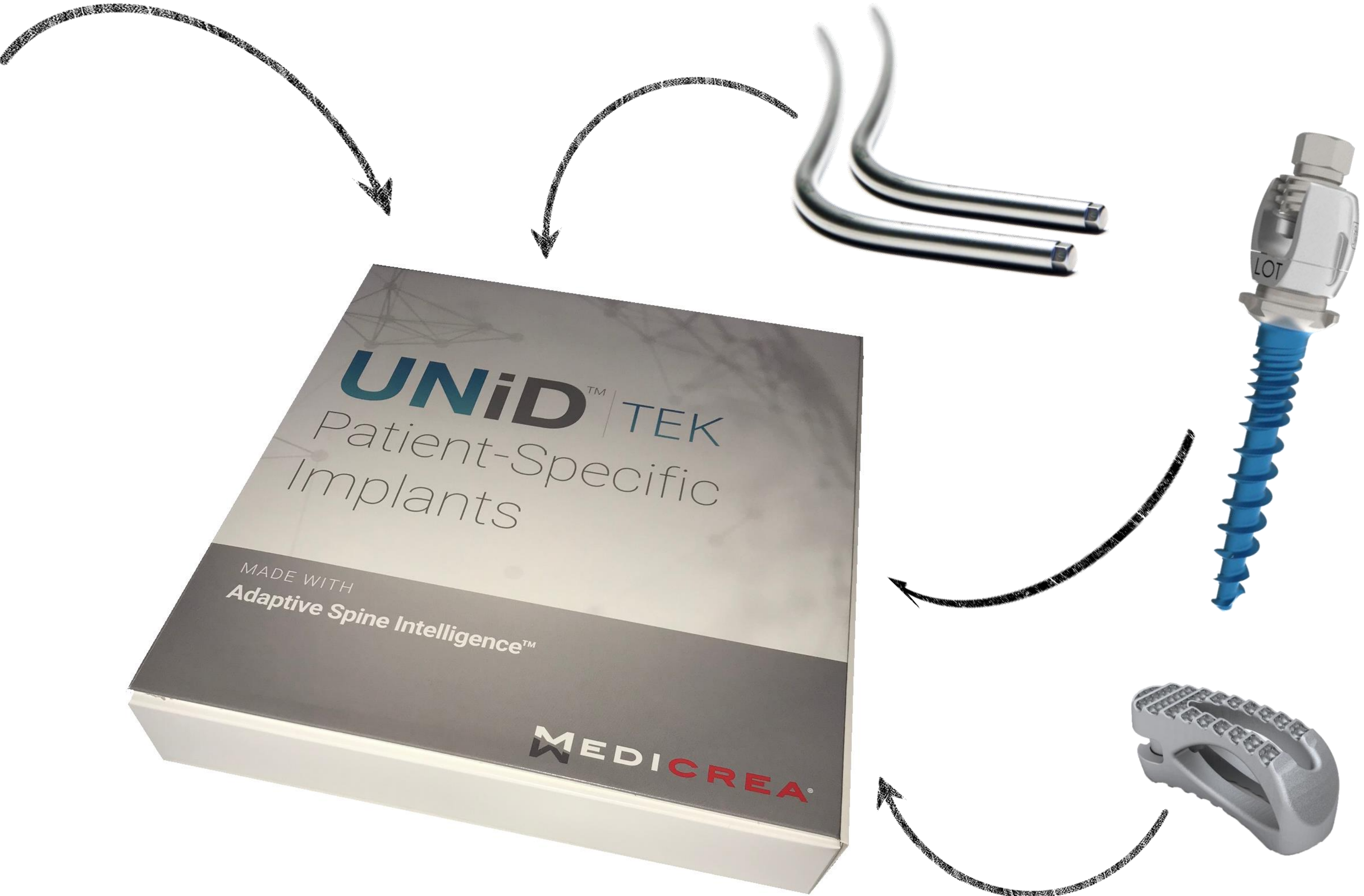
	PRE-OP	PLAN
Pelvic Incidence (PI,°)	67	67
Lumbar Lordosis (LL,°)	81	67
Thoracic Kyphosis (TK,°)	68	45
Sagittal Vertical Axis (SVA,mm)	-99	-8
Pelvic Tilt (PT,°)	35	25
C2 T1 Pelvic Angle (CTPA,°)	9	6
C2C7 SVA (mm)	57	44

UNiD Rod Length 510.8mm
Sagittal Alignment
 PI 25.4°
 PT 17.4°
 LL 57.1°
 T11 LL 9.3°
 SVA -7.7mm

NOTES:

CALIBRATION TYPE	AGE	GENDER	CASE ID	PATIENT ID	SURGERY DATE
EOS	71	F	0VBLJNUQ	0VBLJNUQ	November 12, 2018

medicrea.com leading personalized spine



SCALABILITY

UNID LAB Engineers

- Centralized (New York & Lyon)
- Biomedical Engineering undergrad from college
- 3 months training to full certification
- Initial Engineer relationship migrates to anonymous
- Platform optimized for workflow efficiency with software and automation

UNID Consultants

- Per hospital site for integration into clinic
- Undergrad from college with passion for health
- 3-6 months deployment
- Immediate business impact
- Importance of the “handshake” with surgeons

DATA access

- Cloud-based solution with Web App and Mobile
- HIPPA compliant with Encrypted Data at AWS
- BAA's and security reviews for PACS/EMR Access
- The UNID Consultant model allows immediate XRay access, while working the technical and administrative protocols of each hospital.

Manufacturing

- UNiD Rod = 6 days lead time, 10 days guarantee
- Today's capacity in Lyon = 4000 cases per year
- 6 months to set up USA based production capacity
- Internal 3D printing machine & expertise

APPENDIX

Profit & Loss

in € millions

09/30/2018 09/30/2017































Sales	24 240	21 149
Cost of sales	(7 395)	(5 720)
Gross margin	16 845	15 429
%	69%	73%
Research & development costs	(2 159)	(1 360)
Sales commissions	(2 629)	(2 267)
Sales & marketing expenses	(12 313)	(11 562)
General and administrative expenses	(5 755)	(5 546)
Operating income before non-recurring expenses	(6 011)	(5 306)
Other operating income and expenses	(466)	(271)
Operating income before share-based payments	(6 477)	(5 577)
Share-based payments	(632)	(520)
Operating income after share-based payments	(7 109)	(6 097)
Cost of net financial debt	(1 669)	(1 681)
Other financial (expenses) / income	23	(540)
Income / (loss) before tax	(8 755)	(8 318)
Tax (charge) / income	239	71
Consolidated net income/(loss)	(8 516)	(8 246)
EBITDA	(1 439)	(1 391)

APPENDIX

Balance Sheet

<i>in € millions</i>	09/30/2018	2017	2016
Goodwill	8 420	2 627	2 628
Intangible assets	8 170	7 883	6 071
Property, plant and equipment	10 702	10 772	10 099
Non-current financial assets	652	686	938
Deferred tax assets	1 993	1 185	1 046
Total non-current assets	29 937	23 153	20 782
Trade receivables	6 162	3 973	5 159
Inventories	10 382	9 813	8 726
Trade payables	(5 014)	(4 673)	(6 001)
Other receivables / payables	(1 626)	(334)	1 220
Working capital	9 904	8 779	9 104
in % of Sales	31%	32%	31%
Other provisions	872	800	1 638
Other debts	5 900		
Net equity	16 669	21 790	14 081
FINANCIAL INDEBTEDNESS	16 401	9 342	14 165
Incl. Convertible Bonds	14 237	13 458	12 508
TOTAL CAPITAL EMPLOYED	33 070	31 132	28 248

APPENDIX - BENEFITS SUMMARY

	 PATIENT	 SURGEON	 HOSPITAL	 3 RD PARTY PAYER	 MEDICREA
IMPROVED OUTCOMES					
TIME SAVINGS					
REDUCED COST					
INTRA-OP CONFIRMATION					
OPTIMIZED INVENTORY					
MARKETING DIFFERENTIATION					
SURGEON BUDGET VALIDATION					
LEGAL PROTECTION AVOIDING LITIGATION					

Thank you.

$$y^{(n)} = y^n + \Delta t [(a+b+c+d)(f)_{i,n}] + (\Delta t)^2 \left[\left(\frac{b}{2} + \frac{c}{2} + d \right) \left(\frac{\partial f}{\partial t} + f \frac{\partial f}{\partial y} \right)_{i,n} \right] + \frac{(\Delta t)^3}{2} \left[\left(\frac{b}{4} + \frac{c}{4} + d \right) \left(\frac{\partial^2 f}{\partial t^2} + 2f \frac{\partial^2 f}{\partial t \partial y} + f^2 \frac{\partial^2 f}{\partial y^2} \right)_{i,n} + \left(\frac{c}{2} + d \right) \left(\frac{\partial f}{\partial t} + f \frac{\partial f}{\partial y} \right)_{i,n} \left(\frac{\partial f}{\partial y} \right)_{i,n} \right] + \frac{(\Delta t)^4}{6} \left[\left(\frac{b}{8} + \frac{c}{8} + d \right) \left(\frac{\partial^3 f}{\partial t^3} + 3f \frac{\partial^3 f}{\partial t^2 \partial y} + 3f^2 \frac{\partial^3 f}{\partial t \partial y^2} + f^3 \frac{\partial^3 f}{\partial y^3} \right)_{i,n} \right] + \frac{3c}{8} + \frac{3d}{4} \left(\frac{\partial^2 f}{\partial t^2} + 2f \frac{\partial^2 f}{\partial t \partial y} + f^2 \frac{\partial^2 f}{\partial y^2} \right)_{i,n} \left(\frac{\partial f}{\partial y} \right)_{i,n} + \frac{3d}{2} \left(\frac{\partial f}{\partial t} + f \frac{\partial f}{\partial y} \right)_{i,n} \left(\frac{\partial f}{\partial y} \right)_{i,n}^2 + \frac{3c}{4} + 3d \left(f \right)_{i,n} \left(\frac{\partial f}{\partial t} + f \frac{\partial f}{\partial y} \right)_{i,n} \left(\frac{\partial^2 f}{\partial y^2} \right)_{i,n} + \frac{3c}{4} + 3d \left(\frac{\partial f}{\partial t} + f \frac{\partial f}{\partial y} \right)_{i,n} \left(\frac{\partial^2 f}{\partial t \partial y} \right)_{i,n} + \frac{(\Delta t)^5}{24} \left[\left(\frac{b}{16} + \frac{c}{16} + d \right) \left(\frac{\partial^4 f}{\partial t^4} + 4f \frac{\partial^4 f}{\partial t^3 \partial y} + 6f^2 \frac{\partial^4 f}{\partial t^2 \partial y^2} + 4f^3 \frac{\partial^4 f}{\partial t \partial y^3} + f^4 \frac{\partial^4 f}{\partial y^4} \right)_{i,n} + \dots \right] + O((\Delta t)^6 f^{(6)})$$

$$W = \frac{1}{2\mu} \left[\frac{\Psi^2 \pi^2}{h^2} \sum_{n=1}^{\infty} a_{TK}^2 n^2 (m/4) + \frac{\Psi^2 \pi^2}{a^2} \sum_{n=1}^{\infty} a_{TK}^2 m^2 (m/4) + \Psi^2 \pi \left(\mu^2 + \sum_{n=1}^{\infty} 8n \gamma_n^2 a_{TK}^2 (m^2) \right) \right]$$
$$W = \frac{\Psi^2 \pi}{2\mu} \left[\mu^2 + \sum_{n=1}^{\infty} 8n \gamma_n^2 a_{TK}^2 (m^2) \right]$$

$$\begin{aligned} \left(\gamma_4 \frac{\partial}{\partial x_4} + \gamma_4 \frac{ic}{hc} A_0 + \frac{TK}{h} \right) \psi &= 0 \\ \left(\gamma_4 \frac{\partial}{\partial x_4} + \gamma_4 \frac{\partial}{\partial x_4} + \gamma_4 \frac{ie}{hr} A_0 + \frac{TK}{h} \right) \psi &= 0 \\ \left(c \gamma_4 \frac{\partial}{\partial x_4} - i \gamma_4 \frac{\partial}{\partial t} - \gamma_4 \frac{ie}{hr} - \frac{TK^2}{h} \right) \psi &= 0 \\ \left(hc \gamma_4 \gamma_1 \frac{\partial}{\partial x_4} - SS \frac{\partial}{\partial t} - PULL - TK^2 \gamma_4 \right) \psi &= 0 \\ hc \gamma_4 \gamma_1 \frac{\partial}{\partial x_4} \psi - \left(SS \frac{\partial}{\partial t} - PULL - TK^2 \gamma_4 \right) \psi &= 0 \\ ic \begin{pmatrix} 1 & 0 \\ 0 & -1 \end{pmatrix} \begin{pmatrix} 0 \\ ic \end{pmatrix} \frac{\partial}{\partial x_4} \psi - \left(SS \frac{\partial}{\partial t} - PULL - TK^2 \gamma_4 \right) \psi &= 0 \\ c \begin{pmatrix} 0 & -SS \\ -SS & 0 \end{pmatrix} \frac{\partial}{\partial x_4} \psi - \left(SS \frac{\partial}{\partial t} - PULL - TK^2 \gamma_4 \right) \psi &= 0 \\ c \begin{pmatrix} 0 & \sigma_{ip} \\ \sigma_{ip} & 0 \end{pmatrix} \begin{pmatrix} \psi_A \\ \psi_B \end{pmatrix} = \begin{pmatrix} SS \frac{\partial}{\partial t} - V(r) - mc^2 & 0 \\ 0 & SS \frac{\partial}{\partial t} - PULL - TK^2 \end{pmatrix} \begin{pmatrix} \psi_A \\ \psi_B \end{pmatrix} \\ c \begin{pmatrix} 0 & \sigma_{ip} \\ \sigma_{ip} & 0 \end{pmatrix} \begin{pmatrix} \psi_A \\ \psi_B \end{pmatrix} = \begin{pmatrix} E - V(r) - mc^2 & 0 \\ 0 & E - PULL - TK^2 \end{pmatrix} \begin{pmatrix} \psi_A \\ \psi_B \end{pmatrix} \end{aligned}$$

