## Medical and Biomedical Applications of Shock Waves



## **Contents**

1	Intro	duction	1
2	Brief	Historical Background	5
3	Shock	k Waves as Used in Biomedical Applications	19
	3.1	Introduction	19
	3.2	Pressure and Pressure Waves	20
	3.3	Power and Intensity	26
	3.4	Focal Zones and Penetration Depth	27
	3.5	Energy and Impulse	30
	3.6	Recording of Acoustic Cavitation and Shock Wave Fields	33
4	Shock	k Wave Interaction with Matter	43
	4.1	Introduction	43
	4.2	Propagation and Attenuation	44
	4.3	Reflection and Refraction	48
	4.4	Diffraction	50
	4.5	Compression, Tear, and Shear Forces	52
	4.6	Hopkinson Effect	54
	4.7	Acoustic Cavitation	55
	4.8	Circumferential Compression	68
	4.9	Other Fragmentation Mechanisms	69
	4.10	Radiation Pressure	69
	4.11	Sonoluminescence	70
	4.12	Mechanisms of Tissue Damage During SWL	71
	4.13	Interaction of Shock Waves with Tissue During ESWT	77
5	Shock Wave Lithotripsy		83
	5.1	Introduction	83
	5.2	Electrohydraulic Lithotripters	91
		5.2.1 Single Spark-Gap Shock Wave Sources	92
		5.2.2 Dual Spark-Gap Shock Wave Sources	111

	5.3	Electromagnetic Lithotripters 114
		5.3.1 Flat Coil Shock Wave Sources
		5.3.2 Cylindrical Coil Shock Wave Sources
		5.3.3 Conical Coil Shock Wave Sources
		5.3.4 Self-Focusing Shock Wave Sources
	5.4	Piezoelectric Lithotripters 12
		5.4.1 Self-Focusing Shock Wave Sources
		5.4.2 Non-Spherical Piezoelectric Shock Wave Sources 133
	5.5	Other Shock Wave Sources
		5.5.1 Laser Shock Wave Sources 130
		5.5.2 Microexplosive Shock Wave Sources
		5.5.3 Combined Shock Wave Sources
		5.5.4 Multichannel Discharge Shock Wave Sources
	5.6	Shock Wave Lithotripsy in Urology
		5.6.1 Contraindications
		5.6.2 Pediatric Patients
		5.6.3 Obese Patients
		5.6.4 The Focal Size
		5.6.5 The Shock Wave Rate
		5.6.6 Voltage-Stepping and Number of Shock Waves
		5.6.7 Prophylactic Shock Waves
		5.6.8 Shock Wave Coupling
		5.6.9 Imaging Systems and Patient Positioning 160
		5.6.10 Computed Tomography Attenuation Numbers 16.
		5.6.11 Stone Size, Composition and Location 169
		5.6.12 Efficiency Evaluation
		5.6.13 Final Comments and Recommendations
	5.7	Shock Wave Lithotripsy for Gallbladder, Pancreatic
		and Common Bile Duct Stones
	5.8	Shock Wave Lithotripsy for Salivary Gland Stones 18
	5.9	Development and Future of SWL
6	Extra	corporeal Shock Wave Therapy
v	6.1	Introduction
	6.2	Focused, Defocused, and Planar Pressure Wave Sources
	6.3	Ballistic Sources
	6.4	Other Shock Wave Sources for ESWT
	6.5	Pain Relief
	6.6	Plantar Fasciitis
	6.7	Calcaneal Spur
	6.8	Achilles Tendinopathy
	6.9	Tendinopathy of the Shoulder
	6.10	Epicondylitis of the Elbow
	6.11	Patellar Tendinopathy
	6.12	Bone Healing

Contents	xvii

	6.13	Bone Vascular Diseases	226
	6.14	Spasticity	228
	6.15	Wound Healing	232
	6.16	Aesthetic Dermatology	237
	6.17	Heart Diseases	241
	6.18	Chronic Pelvic Pain Syndrome	245
	6.19	Peyronie's Disease	247
	6.20	Erectile Dysfunction	247
	6.21	Shock Wave Acupuncture	249
	6.22	ESWT in Veterinary Medicine	250
7	Nove	Uses and Potential Applications	251
	7.1	Introduction	251
	7.2	Needleless Injection and Small Shock Tubes	252
	7.3	Ablation and Neurosurgery	254
	7.4	Cell Transfection and Oncology	256
	7.5	Bacterial Transformation	281
	7.6	Transformation of Filamentous Fungi	286
	7.7	Bactericidal and Fungicidal Effects of Shock Waves	291
	7.8	ESWT in Dentistry	298
D.	ferenc		202