Sawtooth Reference	year	title	T/C/E	n	Geom	resolution	L/N	model	result
Eriksson and Wahlberg, Phys. Plasmas, **9** 1606	2002	Effect of combined triangularity and ellipticity on the stability limit of the ideal internal kink mode in a tokamak	T	**1**	T		L	Ideal MHD	The effect of combined positive ellipticity and triangularity is stabilizing. This extends the work of Wahlberg, Phys. Plasmas 5, 1387 (1998)
Huysmans, Hender, Hawkes, Litaudon, Submitted to Phys. Rev. Lett	2001	MHD Stability of Advanced Tokamak Scenarios with Reversed Central Current: an explanation of the Current Hole	C	0	C	0/0 and 0/1 only	QL	finite beta three-field reduced MHD	simple model with only 2-modes qualitatively agrees with data
Hawkes, N.C. et al, PRL **87** 115001	2001	Observation of Zero Current Density in the Core of JET Discharges with Lower Hybrid Heating and Current Drive	E	0	C	-			Current ramping and LHCD produce a region of zero current density, implying the existence of a physical mechanism preventing it from becoming negative.
Reimerdes, et al, Plasma Phys. Control. Fusion **42** 629	2000	Effect of triangular and elongated plasma shape on the sawtooth stability	E						Experiments were done on TCV to determine the dependence of the sawtooth period and amplitude on the shape of the poloidal plasma cross section. Relation to ideal MHD theory.
Sugiyama and Park, Phys. Plasmas, **7** 4644	2000	A nonlinear two-fluid model for toroidal plasma	C	1	C	$S=3x10^4$	N	two-fluid MHD	Ion diamagnetic drift stabilizes 1/1 mode, explained due to flow pattern
Nishimura, Callen, and Hegna, Phys. Plasma **6** 4685	1999	Onset of high-n ballooning modes during tokamak sawtooth crashes	C	1	T	500/151		finite beta, three-field reduced MHD	at high β, 1/1 mode induces unstable high-n ballooning modes which induce stochasticity and lead to incomplete reconnection
Hastie RJ, Astrophysics and Space Science **256** 177	1998	Sawtooth Instability in Tokamak Plasmas				-			not in PPPL library
Wahlberg, Phys. Of Plasmas, **5** 1387	1998	Analytical stability condition for the ideal m=n=1 kink mode in a toroidal plasma with elliptic cross section	T						Ellipticity has a strong destabilizing effect on the kink mode. Effects of triangularity not considered.

Aydemir, A, PRL **78** 4406	1997	Nonlinear m=1 Mode and Fast Reconnection in Collisional Plasmas	C	1	C	dynamic	N	low-β reduced two-field MHD	exponential nonlinear growth (but slower than linear)
Lutjens and Luciani, Phys. Plasmas 4 4192	1997	Stability thresholds for ballooning modes driven by high β internal kinks	C	1	T	??	QL	full MHD	The nonlinear destabilization described in [Park,1995] is looked at for a more general class of parameters. Nonlinear destabilization occurs if the initial equilibria is close to marginal stability for the n>3 modes.
Wang and Bhattachargee, Phys.Plasmas **4** 1173	1997	Comment on "Collisionless m=1 reconnection in tokamaks"	T	1		-			Rodgers and Zakharov 1996 paper citing explosive growth due to generalized Ohm's law agrees with 1993 and 1995 W&B papers and with Aydemir.
Rogers and Zakharov, Phys. Plasmas **4** 1175	1997	Response to "Comment on 'Collisionless m=1 reconnection in tokamaks' "	T	1		-			disagree with equation used by W&B linking the poloidal flow speed along the reconnection layer to the plasma pressure
Chang, Park, Fredrickson, et al. PRL **77** 3553	1996	Off-Axis Sawteeth and double-tearing reconnection in reversed magnetic shear plasmas in TFTR	E/C	1	C	S=105-6	N	resistive MHD	2-types of off-axis sawtooth when qmin crosses 2 due to double-tearing: off-axis and on-axis. Simulation of off-axis. Time-scales similar to q=1 sawtooth.
Nagayama, McGuire, Bitter, et al, Phys. Plasmas **3** 1647	1996	Tomography of full sawtooth crashes on TFTR	E						Reconnection is 3-D, localized on bad curvature side. Experimental results do not agree with 2D models. Q-profile does not change during crash
Nagayama, G.Taylor, M.Yamada, et al	1996	ECE Image reconstruction of partial sawtooth crashes in Ohmic Plasmas	E			-			Partial sawteeth sometimes observed when qa < 3. Caused by (2,2) or (3,3) mode. The (1,1) mode normally occurs after the partial crash.
Porcelli, et al, Plasma Phys. Control. Fusion **38** 2163	1996	Model for the sawtooth period and amplitude	T						A sawtooth model for ITER is presented. Crash is triggered by m=1 mode driven by MHD, high energy particles, and thermal trapped particles. Kadomtsev or incomplete reconnection.

Rodgers and Zakharov, Phys. Plas. **3** 2411	1996	Collisionless m=1 reconnection in tokamaks	T/C	1	Slab	335/261	N	two-field, two-fluid, reduced	fast nonlinear growth in early stage of nonlinear reconnection
Haas and Thyagaraja, Plasma Phys. Controlled Fusion 37 415	1995	Turbulence and the nonlinear dynamics of sawteeth in tokamaks	T					simple model equations	Turbulence relaxation model keeps q<1 and fixed.
Park, Fredrickson, Janos, et al, Phys. Rev. Lett **75** 1763	1995	High-β Disruption in Tokamaks	C		T		N	resistive MHD, but not entirely self-consistent	ideal (1,1) saturated state causes toroidally localized high-n ballooning mode produces local pressure bulge which develops into disruption
Rogers and Zakharov, Phys. Plasmas **2** 3420	1995	Nonlinear ω* stabilization of the m=1 mode in tokamaks	T/C	1	Slab			3-field, two fluid reduced	m=1 mode with q(0) < 1 can be linearly stabilized by w*. Regimes that are linearly unstable can be non-linearly stable due to w* effects, with non-singular current layer.
Soltwisch and Koslowski, Plasma Phys. Controlled Fusion **37** 667	1995	Sawtooth modulation of the poloidal field in TEXTOR under ohmic heating conditions	E						In reproducible ohmic plasmas, q0 = 0.73 and dq0 = 0.06 during the ramp. Poloidal field perturbation localized at the large major radius side of the q=1 surface. May agree with [Park,1991]
Wang and Bhattachargee, Phys Plasmas **2** 171	1995	Nonlinear dynamics of the m=1 kink-tearing instability in a modified MHD model	T		C			3-field, two fluid reduced	Electron pressure gradients can cause near-explosive growth in the nonlinear regime of a m=1 island, followed by a rapid decay phase. Model could explain fast crash times, sudden onset, and incomplete reconnection.
Biskamp and Drake, Phys. Rev. Lett **73** 971	1994	Dynamics of the Sawtooth Collapse in Tokamak plasmas	C	1	C		N	2-fluid reduced MHD with electron inertia and viscosity	fast reconnection driven by electron inertia occurs in two steps. A fast Kadomtsev-type reconnection is followed by a rapid reformation of a q0 < 1 configuration, driven by the strong flows.
Gimblett and Hastie	1994	Calculation of the post-crash state and 1 1/2D simulation of sawtooth cycles	C	1	C		N	1 1/2D model of sawtooth	resistive interchange model keeps q(0) < 1 during the sawtooth cycle
Levinton, Zakharov, Batha, et al, Phys Rev. Lett **72** 2895	1994	Stabilization and onset of sawteeth in TFTR	E	1					In TFTR q(0) < 1 , normally, but sawteeth are not always present. Small change during crash implying full reconnection does not occur. Theory predicts ideally unstable. Presence or absence of sawteeth agrees well with ω* criteria in [Zakharov,1993]

Rice and Hooper, Nucl Fusion **34** 1	1994	Poloidal field measurements during sawteeth and disruptions on MTX	E					Polarimeter measurements on MTX show q_0 ~ 0.7-0.85 during sawteeth, with Δq_0 ~ 0.01 during the sawtooth
Yamada, Levinton, Pomphrey, Phys. Plasma **1** 3269	1994	Investigation of magnetic reconnection during a sawtooth crash in a high-temperature tokamak plasma	E					Electron temperature flattens in ~ 200 ms, but q-profile hardly changes. q0 = 0.7, Dq0 < 0.1, observations agree with Baty, et al (1993)
Biskamp and Drake, Proceedings of the 15th IAEA Conference, Seville, IAEA-CN-60/D-7, Vol 3, p261	1994	Dynamics of the Sawtooth Collapse in Tokamak plasmas	C					Same basic story as in Biskamp and Drake, PRL 73 971 (1994)
Zakharov, Levinton, Batha, et al, Proceedings of the 15th IAEA, Seville, IAEA-CN-60/D-19, Vol 3, p 407	1994	Onset and stabilization of sawtooth oscillations in tokamaks	E/T					for finite amplitude perturbations, the influence of the ideal mode disappears and the criteria of ω^* - stabilization of the collisionless m=1 reconnection mode determines the sawtooth-free operational space in tokamaks
Baty, Luciani, and Bussac, Phys. Fluids B **5** 1213	1993	Field line stochasticity during the m=1 reconnection	C	1 T	$S=10^5$, 200x10x11	N	resistive MHD	Toroidal modulation of the m=1 resistive mode drives sidebands, and different magnetic island chains with m up to 10 overlap, leading to an annular stochastic region. This can expel the electron temperature in less than 100 microsec, removing the drive for the instability, and the central core could be pushed back without change in the value of q(0).
Levinton, Batha, Yamada, Zarnstorff Phys Fluids B 5 2554	1993	q-profile measurements in TFTR						q0 = 0.7, Dq0 < 0.1 during crash. q=1 radius changes less than 1 cm. Some discharges with same q0 < 1 have 1,1 activity but no sawteeth
Ottaviani and Porcelli, Phys. Rev. Lett. **71**, 3802	1993	Nonlinear collisionless magnetic reconnection	C	1 slab	1026/64	N	two-field model with electron inertia	quasi-explosive time behavior in early nonlinear stage with formation of current density sublayer narrower than the skin depth.
Waelbroeck, Phys. Rev. Lett. **70** 3259	1993	Onset of the sawtooth crash	T	1 C			low-β reduced two-field MHD	tearing vs kink-tearing: gives theory basis why sawteeth in toroidal geometry fundamentally different than in cylindrical

Wang and Bhattachargee, Phys. Rev. Lett. **70**, 1627	1993	Nonlinear dynamics of the m=1 instability and fast sawtooth collapse in high-temperature plasmas	T	C		N	four-field model	analytical model explaining many features of [Aydemir,1992] Explosive growth followed by rapid decay are shown to follow from Hall term. Electron inertia not important
Wolf, O'Rourke, Edwards et al, Nucl Fusion **33** 663	1993	Comparison of poloidal field measurements on JET	E					Measurements of q0 on JET by both Faraday and MSE agree and show q0 ~ 0.7-0.85 throughout the sawtooth cycle: partial reconnection does occur
Wroblewski, Phys Rev. Lett, **71** 859	1993	Evidence of the Complete Magnetic Reconnection during a sawtooth collapse in a tokamak	E					In DIII, q_0 is measured by MSE to be near 1.0, and $\Delta q_0 = 0.06$. [Wroblewski,1991] may be wrong
Zakharov,Rodgers, Migliuolo, Phys. Fl. B **5**, 2498	1993	The theory of the early nonlinear stage of m=1 reconnection in tokamaks	T	1 C		L/N	three-field model	Hall term dominates in Ohm's law. Gives fast experimental crash times. Density and temperature gradients are stabilizing. (criteria given) Nonlinear cancellation of the w* stabilization is possible triggering mechanism.
Aydemir, A, Phys.Fluids B **4** 3469 (1992)	1992	Nonlinear studies of m=1 modes in high-temperature plasmas	C	1 C	600/256	N	four-field reduced model with hyperresistivity	accelerated nonlinear growth with 2-fluid physics. Y-point becomes X-point. Electron inertia probably not essential. Complete reconnection.
Coppi and Detragiache, Phys. Lett A **168** 59	1992	Magnetic topology transitions in collisionless plasmas	T					It is shown that collisionless processes can lead to fast sawtooth crash times, but only if the growth rate exceeds the drift frequencies.
Kolesnichenko, Yakovenko, et al, Phys Rev Lett **68** 3881	1992	Sawtooth Oscillations with the central safety factor, q0, below unity	T	1 C			simple ideal MHD conservation laws	cartoons showing it may be possible to have reconnection and keep q0 < 1
Lutjens, et al, Nuclear Fusion 32 1625	1992	Ideal MHD stability of internal kinks in circular and shaped tokamaks	C	1 T		L	ideal MHD	The internal kink is significantly destabilized by ellipticity.
Nagayama and Edwards, Rev. Sci. Instr **63** 4757	1992	Rotational soft x-ray tomography of noncircular tokamak plasmas	E					Pictures of soft X-ray signals in slow sawtooth crash in JET. Identical in structure to TFTR (Nagayama,1991)
Rice, Rev. Sci. Instrum **63** 5002	1992	Fifteen chord FIR polarimetry system on MTX	E					on MTX q_0 remains at .78 +- 0.08 during sawtooth oscillations.

Soltwisch H Plasma Phys. Control. Fusion **34** 1669 (Review Article)	1992	Current Density Measurements in Tokamak Devices	E					Confusing results of q_0=1 reported on ATC, ASDEX, TCA. Low values of $q_0 < 0.8$ reported on PBX-M, DIII, TEXTOR, JET, PDX, TOKAPOLE II.
Zakharov,Rodgers, and Coppi, Phys Fluids B **4** , 3285	1992	Two-fluid MHD description of the internal kink mode	T			L		The scale length for electron and ions decouple. For the ions, the scale length is $\rho_S = C_S/\Omega_{ci}$. 2-fluid equations agree well with kinetic studies.
Aydemir, Phys. Fluids B **3**, 3025	1991	Linear studies of m=1 modes in high-temperature plasmas with a four-field model	C	1 C		L	four-field reduced model with finite electron inertia	The four-field model reproduces dispersion relations obtained with more complete kinetic treatments.
Berk, Mahajan, Zhang, Phys. Fluids B 3 351	1991	m=1 kink mode for layer widths comparable to the ion Larmor radius	T				FLR MHD	strong dependence of stability result on the local shear at the q=1 surface
Biskamp, Phys. Fluids B **3**, 3353 (1991)	1991	Algebraic nonlinear growth of the resistive kink instability	T	1 C		N	reduced two-field resistive MHD	geometrical modifications to slab Sweet-Parker theory give increased resistive growth rates.
Drake and Kleva, Phys. Rev. Lett 66 1458	1991	Collisionless reconnection and the Sawtooth Crash	C	1 slab	1000/132	N	isothermal compressible MHD with electron inertia and anomalous current diffusion	Electron inertia by itself cannot produce fast reconnection times. However, the addition of a anomalous current diffusion term, due to instability of the current layer, can lead to fast reconnection.
Lichtenberg, Itoh, et al, Nucl. Fusion 32, 495	1991	The role of stochasticity in sawtooth oscillations	T					Stochastization of field lines , resulting from the interaction of the 1,1 helical mode with other harmonics plays an important role in the sawtooth. It leads to enhanced values of electron and ion viscosity and thermal conduction.
Nagayama, McGuire, Bitter, et al, Phys. Rev. Lett **67** 3527	1991	Analysis of Sawtooth Oscillations using simultaneous measurement of electron cyclotron emission imaging and X-Ray tomography on TFTR	E				MHD + stochasticity enhanced transport coefficients	Analysis of temperature data indicate a full thermal reconnection, but no magnetic measurements were used and thus nothing can be said about q0 or flux surfaces.

O.Rourke J Plasma Phys. Control. Fusion 33 289	1991	The change in the safety factor at a sawtooth collapse	E					in JET, $q_0 = 0.7$ while the change during the sawtooth is $\Delta q_0 < .05$. Hence, complete reconnection of the poloidal flux does not take place.
Park, Monticello, Fredrickson, and McGuire Phys. Fluids B **3** 507	1991	Finite pressure effects on sawtooth oscillations	C	1 T	S=3x105,200 radial	N	resistive MHD	finite p0 or shaping cause a toroidal bulge at the large R side, causing an annular stochastic region outside q=1. However, computes full Kadomtsev reconnection
Porcelli, Plasma Phys Controlled Fusion, **33**,1601	1991	Fast Particle Stabilization	T					The stabilization of plasma macroscopic instabilities by high energy particles is shown to be a consequence of the conservation of the third adiabatic invariant.
Porcelli, Phys. Rev. Lett. 66 425	1991	Collisionless m=1 tearing mode	T	1 slab		L	fluid electrons with inertia	In the collisionless regime, magnetic reconnection occurs because of finite electron inertia, and the ion gyroradius replaces the skin depth as the width of the mode boundary layer. Fast growth rates ~ 50-100ms are found for JET parameters
Wesson, Edwards, Granetz, Nucl. Fus **31** 111	1991	Spontaneous m=1 instability in the JET sawtooth collapse	E					Model in [Jahns,1978] or [Aydemir,1989] does not describe JET sawteeth in either the time scale, flow pattern, or time-development of the growth rate. Sudden appearance of the fast growth rate cannot be understood by standard linear theory.
Wroblewski and Lao, Phys Fluids B 3 2877	1991	Determination of the safety factor in sawtoothing discharges in DIII-D	E					Here it is reported that $q_0 < 1$ during sawtooth discharges, and $\Delta q_0 \sim .05$. However, this is somewhat retracted in a later article by the same author[1993]
Aydemir, Phys. Fluids B **2** 2135	1990	MHD modes driven by anomalous electron viscosity and their role in fast sawtooth crashes	C	1 T	S=108, 765/48	N	resistive MHD + hyperresistivity	anomalous electron viscosity can lead to faster growth rates for the crash phase, in approximate agreement with experiment. However, still computes full reconnection
Coppi, et al, Phys Fluids B 2 927	1990	Global modes and high-energy particles in ignited plasmas	T					Fusion-produced alpha particles with trapped orbits can stabilize m=1 internal modes in an ignited plasma. There are stable and unstable regimes.
Janicki, C., et al., Nucl. Fusion 30 950	1990	Tomographic analysis of compound sawteeth on the TDV	E					High resolution tomographic analysis of soft X-ray emission show details of compound sawtooth, which indicates partial reconnection. Time scales too fast for Kadomtsev.

Park, W. and Monticello, D. Nucl. Fus **30** 2413 (1990)	1990	Sawtooth Oscillations in Tokamaks	C	1 T	S=106	N	resistive MHD	neoclassical resistivity, complete reconnection, Δq_0=0.2, $t_{ST} \sim 9R^2T^{3/2}/Zeff$
Rogister,et al, Phys. Fluids B 2 953	1990	The mechanism of sawtooth precursors and sawtooth relaxations	T	1		L	resistive MHD	It is argued that delta-prime for the m=1 depends sensitively on the shear and current density at the q=1 surface. This sensitivity of growth rate to plasma parameters could account for the sawtooth crash.
Wesson, Nucl Fusion **30** 2545	1990	Sawtooth reconnection	T	1 C			resistive MHD + electron inertia	The electron inertia term in ohm's law must be kept in the reconnection layer. Using this in a modified Sweet-Parker theory shows it will increase the predicted crash time and layer width in JET by 10.
Aydemir, Wiley, and Ross Phys. Fluids B **1** 774	1989	Toroidal studies of sawtooth oscillations in tokamaks	C	1 T	S=105-6, 100x4x11	N	resistive MHD, eta depends on p, constant kappa.	full reconnection, transition from stable to unstable state with growing n=1 mode half-way through the cycle. Unstable mode grows for 50% of sawtooth period. Shows development and healing of stochastic regions. Note later paper by Wesson[1991] casts doubt on this work.
Campbell, et al in Plasma Phys and CNFR, Nice, 1988, IAEA Vienna Vol I, p377	1989	Sawtooth activity and current density profiles in JET	E					Direct measurement of the q-profile show q(0) is below unity in sawtoothing plasmas and may be 0.6-0.8 during the stable periods.
Levinton, et al Phys Rev. Lett **63** 2060	1989	Magnetic field pitch-angle measurements in PBX-M using MSE	E					Measurements on PBX-M show q(0)=0.86 in ohmic and q(0)=0.77 in NBI plasmas. These are supported by 2 other measurements. In addition, q® is flat out to about a/3 and well blow unity.
Moyer, Goetz, et al, Phys. Fluids B **1** 2139	1989	q measurements during sawtooth oscillations in a low q tokamak	E					q(0) in TOKAPOLE-II is 0.7 during a sawtooth oscillation [note it is not clear if they correctly took plasma shape into account]
Pegorado, Porcelli, et al, IAEA, Niece, 1988, Vol 2, p243, IAEA-CN-50/D-IV-6	1989	Theory of sawtooth stabilization in the presence of energetic ions	T					Energetic particles affect the stability of internal kink modes and can lead to plasma regimes where both sawtooth and fishbone oscillations are suppressed.

Pegoraro, Procelli, et al, Phys. Fluids B 1 364	1989	Internal kink modes in the ion-kinetic regime	T	1	slab	L	collisional electrons, collisionlesss ions	When the width of the singular layer is determined by the mean ion gyroradius, the growth rates are larger than the corresponding ones from fluid theory, and diamagnetic stabilization is weaker.
Sato, et al, Phys. Rev. Lett **63** 528	1989	Supersaturation and nonlinear crash of tokamak sawtooth oscillations	C	1 T	S=3x104 in center ??x??x??	N	resistive MHD	high beta (10%) plasma undergoes kink instability when q(0)=1. Then, second axis forms and q(0) falls to 0.8. Finally, fast ideal time scale reconnection occurs bring q(0) to 1.0. Claim that compressibility is important
Snider, Phys. Fluids B **1** 404	1989	Modification of sawteeth by second harmonic EC heating	E					A factor of 6 increase in sawtooth period is observed when ECE heating is localized at the q=1 surface.
Vlad and Bondeson, Nucl. Fusion **29** 1139	1989	Numerical simulations of sawteeth in tokamaks	C	1 C	S = 107, 200x4	N	low-β reduced two-field MHD + temperature equ.	"Self-consistent" calculation leads to very flat central q profiles with q(0)=1. This q profiles allows a resistive mode to turn on quickly and with a high growth rate. Collapse scales weaker than $S^{1/2}$-more like $S^{1/3}$. Results depend strongly on ratio of viscosity to conductivity. Δq(0) decreases with S.
Waelbroeck, Phys. Fluids B **1** 2372 (1989)	1989	Current sheets and nonlinear growth of the m=1 kink-tearing mode	T	1 C		N	low-β reduced two-field MHD	shows theoretical basis for current-sheet singularity and rapid reconnection
Westerhof, E. et al., Nucl Fusion **29** 1056	1989	Observations of sawtooth postcursor oscillations in JET and their bearing on the nature of the sawtooth collapse	E					Radial Te profile measured with high time resolution with ECE. Shows a m=1 island cold region and displaced hot plasma core. Conclusion that partial and full collapses are related, but with different nonlinear evolution.
Aydemir, Phys. Rev Lett **59** 649	1988	Mechanism for Rapid Sawtooth Crashes in Tokamaks	C	1 T	??x??x??	N	resistive MHD	Ideal instabilities exist for low shear systems even when q(0) > 1. Very sensitive to q' or a off-axis minimum near 1. Speculated to lead to fast crash times.
Campbell, et al, Phys. Rev. Lett **60** 2148	1988	Stabilization of sawteeth with additional heating in the JET tokamak	**E**					The sawtooth instability is suppressed for periods up to 1.6 s when NBI is added. Not clear if it is due to q(0) > 1, or other stabilization of the 1/1 mode.

Charlton, Carreras, Holmes, et al, Phys. Fluids, 31 347	1988	Tokamak m=1 MHD calculations in toroidal geometry using a full set of nonlinear resistive MHD equations	C	1 T	S=105, ??x??x??	N	resistive MHD with "incompressible" or "pressure convection" equation of state	nonlinear results are sketchy, but depend on S, aspect ratio, and equation of state. Incomplete reconnection can be found for "pressure convection", A=4. However, there is a warning that this is valid only for high beta. Transition from resistive kink to resistive tearing at small A and large S.
Coppi, Hastie, Migliuolo, et al	1988	Suppression of Internal Plasma Oscillations by Trapped High Energy Nuclei	T				kinetic MHD	sawteeth are shown to be stabilized by magnetically trapped energetic nuclei
Goedheer and Westerhof Nucl. Fusion **28** 565	1988	Sawteeth, Transport and electron cyclotron heating in T-10	T	1 1D	model	-	1D transport modeling	It is shown that a simple "turbulent model" for sawtooth evolution fits the data much better than the "reconnection model" [Jahns,1978]
H. Soltwisch, Rev. Sci. Instrum 59 1599	**1988**	**Measurement of current-density changes during sawtooth activity in a tokamak by FIR**	**E**					**The axial current density is measured to have an average of q(0)=0.77 with a modulation amplitude of about 8%. This precludes the classical Kadomtsev model.**
Wroblewski, Huang, and Moos, Phys. Rev. Lett. **61** 1724	1988	Determination of the poloidal magnetic field profiles in a tokamak by polarization spectroscopy …	**E**					The on axis safety factor on TEXT is found to be close to 1.0. There is a decoupling of the current and temperature profiles and a flat current density profile in the center of the discharge. Note this contradicts [West,1987]
Hastie, Hender, Carreras, et al, Phys. Fluids 30 1756	1987	Stability of ideal and resistive internal kink modes in toroidal geometry	C	1 T		L	ideal and resistive MHD	Results are presented on the stability of ideal and resistive m=1 internal modes near marginal stability.
Kleva, et al, Phys. Fluids **30** 2119 (1987)	1987	The fast crash of the central temperature during sawteeth in tokamaks.	C	1 C	40x400	N	two-field reduced MHD	It is postulated that q(r) first falls below one at finite radius r_s, while q(0) stays near 1. This leads to "ideal" timescale modes and fast crashes.
McGuire,K. et al, in Plasma Physics and Controlled Nuclear Fusion research 1986 (Proc. 11th Int. Conf. Kyoto,) Vol. 1, IAEA, 421	1987	Coherent and turbulent fluctuations in TFTR	E					three types of sawtooth activity in TFTR: simple, small, and compound. Not explained by Kadomtsev model.

Park, Monticello, and Chu, Phys Fluids **30**, 285	1987	Sawtooth stabilization through island pressure enhancement	C	1 C	N	helical compressible resistive MHD equations	The m=1 mode can saturate when the pressure inside the magnetic island is heated and becomes greater than that of the original core plasma
Izzo R, Monticello DA; Stodiek W, Park W.	1987	Stochasticity and the m=1 mode in tokamaks	C	1			
Soltwisch, Stodiek, et al, IAEA Kyoto Vol 1 p263	1987	Current density profiles in the TEXTOR tokamak	E				The central safety factor in TEXTOR is measured by Faraday Rotation to be as low as 2/3.
Wesson et al, in Plasma Physics and Controlled Nuclear Fusion research 1986 (Proc. 11th Int. Conf. Kyoto,) Vol. 2, IAEA, 3	1987	Sawtooth Oscillations	C	1 C	N	cylindrical, incompressible	Sawtooth oscillations may be quasi-interchange modes, but this requires very flat q profiles with q(0)>1. Does not explain rapid onset of collapse.
West, et al, Phys Rev Lett **58** 2758	1987	Measurement of the rotational transform at the axis of a tokamak	E				q(0) in TEXT is measured to be 0.7-0.8. Note this is later contradicted in [Wroblewski,1988]
Biskamp, Phys. Fluids **29**, 1520	1987	Magnetic reconnection via current sheets	C	1 C	N	two-field reduced MHD	The current sheet at the singular surface can itself become unstable to tearing modes.
Campbell D. J. et al Nucl. Fusion **26** 1085	1986	Sawtooth activity in ohmically heated JET plasmas	E				JET sawtooth do not agree with Kadomtsev model: No precursor for collapse of compound sawteeth. Crash time too fast
Denton, Drake, Kleva, Boyd, Phys. Rev. Lett. **56** 2477	1986	Skin currents and compound sawteeth in tokamaks	C	1 C		two-field reduced MHD with temperature equ.	if the thermal conductivity is small near the axis and increases outward, q(0) stays near 1 but falls below 1 at a finite radius. This leads to both normal and compound sawteeth.
Edwards, Campbell, et al, Phys. Rev. Lett **57** 210	1986	Rapid collapse of a plasma sawtooth oscillation in the JET tokamak	E				The central hot region in JET collapses in about 100 microsec, with a rapid transition to a configuration with poloidal symmetry. Does not agree with Kadomtsev model, but may agree with Wesson,1986
Hazeltine, Meiss, Morrison Phys Fluids **29** 1633	1986	Analytic theory of the nonlinear m=1 tearing mode	T	1 C		two-field reduced MHD	The m=1 tearing mode is shown to continue to grow exponentially well into the nonlinear regime, in contrast to the slow growth of the m>1 modes.
Wesson, J. Pl. Phys. Control. Fus. **28** 243	1986	Sawtooth oscillations	T	1 C		ideal MHD	It is suggested that if q is flat in the center, just above 1, and falls below 1 at a finite radius, a fast sawtooth crash can occur.

Park, Monticello,White., Phys. Fluids **27** 137	1985	Reconnection rates of magnetic fields including the effects of viscosity	C	1 C	S=107, 200x15	N	2D 2-field reduced MHD with scalar resistivity and viscosity	numerical reconnection rate agrees with modified Sweet-Parker when viscosity is large enough. When viscosity is small, reconnection is intermittent or unstable to higher m modes.
Dubois, Pecqet, and Reverdin, Nucl. Fusion **23** 147	1984	Internal Disruptions in the TFR Tokamak: A phenomenological Analysis	E					Detailed analysis of high-speed X-ray data of sawteeth show it does not agree with the total reconnection [Kadomtsev] model. They propose a model where a "turbulent" region grows up around the island at the q=1 surface.
Lichtenberg, Nuclear Fusion **24** 1277	1984	Stochasticity as the mechanism for the disruptive phase of the m=1 tokamak oscillations	T					The disruptive phase of the sawtooth can be caused by the onset of stochasticity caused by the (1,1) mode interacting with the (1,0) toroidal effects.
Manickam, Nuclear Fusion, 24 595	1984	Stability of n=1 internal modes in tokamaks	C	1 T		L	ideal MHD	The internal kink can be stable in a torus at sufficiently low pressure. Ellipticity is destabilizing, and triangularity is stabilizing.
Osborne, Dexter, and Prager, Phys. Rev. Lett **49** 734	1984	Discharges with Safety Factor q(0) < 1 in a Noncircular Tokamak	E					TOKAPOLE II discharges have q(0) =0.6 as directly measured with magnetic probes. Sawtooth oscillations are present, but q(0) remain stationary and below 1 during the sawtooth.
Parail, Pereverzev, Sov. J. Plasma Phys. **6** 14	1983	Internal disruption in a tokamak	T	1				Variation of the Kadomtsev model with the q-profile non-monotonic. Claims to solve the "trigger" problem which Kadomtsev does not.
Basu and Coppi, Phys. Fluids **24** 465	1982	Theory of m=1 modes in collisionless plasmas.	T	1 C				Finite electron mass can destabilize otherwise stable ideal m=1 modes. But a temperature gradient can stabilize. Reconnection layers of the order of the ion gyroradius.
Park, Monticello, White, Jardin Nucl. Fus. **20** 1181	1981	Nonlinear saturation of the internal kink mode	C	1 C	350/30		Ideal MHD	Current singularity forms in ideal MHD
McGuire, Robinson, Nucl. Fus. **19** 505	1980	Sawtooth oscillations in a small tokamak	E					Sawteeth are present in TOSCA with a repetition time of 0.12ms. Comparison with other tokamaks indicate the sawtooth period scales like a reconnection time.

Jahns, Soler, Waddell, et al, Nucl Fus. **18** 609	1979	Internal Disruptions in Tokamaks	T						A model is put forward for the internal disruption and compared with ORMAC data. q(0) drops below 1, tearing mode=> magnetic reconnection=>q(0) > 1
Ara, Basu, Coppi, et al, Ann. Phys **112** 443	1978	Magnetic reconnection and m=1 oscillations in a current carrying plasma	T	1	C		L		gives general theory for linear kink in a cylinder, including ideal, resistive, FLR, electron drift wave, ion-ion collisions. Refers to Coppi, Phys Rev Lett 12 417 (1964) for gyroviscous cancellation. Cannot have layer width < ion gyroradius.
Zakharov, Sov. J. Plasma Phys. **4** 503	1978	Internal kink mode in a tokamak	T	1	T				Supports the calculation given in [Bussac, 1975]
Dnestrovskij, et al, Sov. J. Plasma Phys **3** 9	1977	Numerical simulations of internal-mode relaxation oscillations in a tokamak	C	1	C	1D		transport equations	simple transport equation implementation of the Kadomtsev reconnection model
Coppi, et al, Sov. J. Plasma Phys **2** 533	1976	Resistive Internal Kink Modes	T		C		L	resistive MHD	Considers the 1D theory of internal kink modes with resistive corrections which are the same order.
Sykes and Wesson, Phys. Rev. Lett **37**, 140	1976	Relaxation Instability in Tokamaks	C	1	C	14x14x10		resistive MHD, high beta	Supports the Kadomtsev model, but is in a high-beta cylinder
Waddell, Rosenbluth et al, Nucl. Fusion **16**, 528	1976	Nonlinear growth of the m=1 Tearing Mode	C	1	C	$S=5x10^4$	N	reduced two-field resistive MHD	The m=1 tearing mode grows fast enough in the nonlinear regime to explain the crash times of the present experimental data
Kadomtsev, B.B. Sov. J. Plasma Phys. **1** 389 (1975)	1976	Disruptive instability in tokamaks	T	1	C				Presents basic m=1 reconnection model. Predicts that q(0) < 1 before event, and q(0) = 1 after reconnection
Rosenbluth, Dagazian, Rutherford, Phys Fluids **16**, 1894	1976	Nonlinear properties of the internal m=1 kink instability in the cylindrical tokamak	T		C		N		Shows that the ideal m=1 instability saturates at a small amplitude with a singular current sheet.
Bussac, Phys Rev. Lett. **35** 1638	1975	Internal Kink Modes in Toroidal Plasmas with Circular Cross Sections	T	1				Ideal MHD	The ideal Internal Kink Mode can be stable in toroidal geometry for circular cross section plasmas if the pressure gradient is sufficiently low. This is contrary to the known result in cylindrical geometry.
Rutherford, Phys. Fluids 16 1903	1975	Nonlinear growth of the tearing mode	T						Classic nonlinear tearing mode reference. However, does not apply to the m=1 mode.

Von Goeler, Stodiek, and Sauthof, Phys. Rev. Lett. **33** 1201	1973	Studies of Internal disruptions and m=1 oscillations in tokamak discharges with soft-X-ray techniques	E				first to use the term "sawtooth oscillation"
Shafranov, Sov. Phys. Tech Phys. **15**, 175	1970	Hydromagnetic stability of a current-carrying pinch in a strong longitudinal magnetic field	T	C	L	Ideal MHD	Gives basic cylindrical stability theory, and the condition q(a) > 1

?